SSRC | Speech Science Research Centre

An Investigation into the Ability of Adults with Post-Stroke Aphasia to Learn New Vocabulary

Helen McGrane BSc(Hons)

PhD Thesis, 2006

Queen Margaret University College

EDINBURGH

An Investigation into the Ability of Adults with Post-Stroke Aphasia to Learn New Vocabulary

Helen McGrane BSc(Hons)

A thesis submitted in partial fulfilment of the requirements for the degree of
Doctor of Philosophy
in the discipline of Speech & Language Therapy

Queen Margaret University College
Edinburgh
March 2006

Abstract

Recent studies have established that adults with post-stroke aphasia can learn to establish connections between familiar words and abstract images, and non-words with familiar objects. What has not been investigated was whether adults with aphasia could learn non-words with abstract images/ novel meanings i.e. new vocabulary. The main objective of this study was to investigate whether adults with post-stroke aphasia could learn 'novel' word forms with 'novel' word meanings, despite phonological and/or semantic impairment. Specific research questions included: Can post-stroke adults with aphasia learn new vocabulary? If so, what factors affect their capacity to learn? Is it possible to predict which individuals will learn most successfully? The methodology was developed using preliminary studies both with adults of normal language and cognitive functioning and post-stroke non-aphasic and aphasic adults. It incorporated learning theory and a cognitive neuropsychological model of language. A range of assessments was used to facilitate the capture of new learning. 'New learning' was measured not only in terms of the accurate production of the new stimuli but also the recognition and knowledge of the word forms and meanings of this new vocabulary. In the main investigation twenty novel word forms with 20 novel meanings were taught to 12 aphasic adults (< 65 years), over a four-day period, using an errorless learning paradigm. Immediate recall of these newly learnt representations was investigated as well as delayed recall. Quantitative and qualitative results from a case series of 12 participants are presented and discussed. Despite semantic and phonological difficulties, all but three participants demonstrated substantial learning of the new vocabulary. The participants' range of learning ability (from both immediate and delayed recall data) was analysed in relation to severity of aphasia, cognitive factors (including attention, memory and executive function), as well as variables such as age, months post-stroke and number of years in education. With an intensive training period, these participants with aphasia demonstrate varying degrees of ability for new learning. Possible influencing factors and implications for speech and language therapy rehabilitation are discussed.

Acknowledgements

"…those who hope in the Lord will renew their strength,
they will soar on wings like eagles,
they will run and not grow weary
they will walk and not be faint" Isaiah 40; 31

I cannot count the number of people who have helped me, even in what might seem the smallest of ways. Thank you – you have all contributed greatly to the final completion of this thesis.

Much thanks must go to my Director of Studies and supervisors who helped guide and teach me throughout my research. Dr. Linda Armstrong, go raibh mile maith agat for your guidance, support and friendship and for having patience with my own individual 'learning' style. Thank you Dr. Daphne Waters and Duncan Robb for your invaluable help and advice. Many thanks to Laorag Hunter (Speech and Language Therapist, Dundee) for helping me in a last minute request to review my work. I'm very grateful for all your help.

Particular appreciation must go to all the participants in this investigation – preliminary and pilot study participants from the staff and research students at QMUC and undergraduate students at QMUC for providing normative data for my methodology. A special thank you to all participants with aphasia and your partners for offering your time and energy in order to provide data for this investigation at no benefit to yourselves. It is much appreciated.

Thank you also to the Speech and Language Therapists and managers from Lothian and Fife Trust, Chest, Heart and Stroke, Edinburgh and Telford College, Edinburgh for your help in recruiting participants for this investigation.

The first three years of my PhD was supported by a studentship from QMUC, Edinburgh enabling me to study fulltime.

To all staff and PhD students past and present in Speech and Language Sciences at QMUC, Edinburgh for all your support and encouragement along the way. Thank you to my fellow PhD students at the time – Olga, Ben, Ann, Rebecca, Richard and Fay for your friendship, fun and support. Special thanks to Steve for your IT support and for always being there when my computer took on a life of it's own!! Thanks also to QMUC staff for advice on statistical methods for my data especially Dr. Stuart Wilson who generously gave his time at the eleventh and twelfth hour. Thanks to Dr. Carmel Lum for your advice and support the first three months of my thesis.

Christine Malcolm (Chief Speech and Language Therapist, Fife NHS Trust) I am grateful for all your support, encouragement and study leave when working fulltime. Thanks also to all my work colleagues for their support and encouragement.

For my partner, Peter, my mam and my family– your love and belief in my ability to achieve anything I put my heart to has helped sustain me especially through the past two years. For Smokey our cat who guarded my thesis drafts by sitting on them and remained calm even when the printer was going crazy!! Thanks also to all my friends for their prayers and support when I was going crazy!!

Contents Page

Chapter 1 Introduction to Investigation 1

Chapter 2 Review of the Literature and Investigation Considerations

2.1 Introduction **4**
2.2 What is aphasia? **5**
2.2.1 Recovery from aphasia **7**
2.3 The impact of aphasia **8**
2.3.1 Emotional impact of aphasia **11**
2.3.2 Social functioning with aphasia **12**
2.3.3 Impact of aphasia on the family unit **14**
2.3.4 Active engagement in pleasurable activities with aphasia **15**
2.3.5 Summary **15**
2.4 Rehabilitation of aphasia **18**
2.4.1 The efficacy of aphasia rehabilitation **18**
2.5 The plasticity of the adult brain **21**
2.5.1 The physical processes of the brain **21**
2.5.2 Evidence of plasticity in adults **22**
2.5.3 Evidence of plasticity in the recovery of motor and sensory function **25**
2.5.4 Does plasticity require therapeutic direction? **26**
2.5.5 Evidence of plasticity in the recovery of language functions **29**
2.6 Factors influencing language recovery **32**
2.6.1 Pre-morbid factors **32**
2.6.1.1 Age at onset **32**
2.6.1.2 Years of education **34**
2.6.1.3 Cognitive reserve **35**
2.6.2 Biological limitations **37**

2.6.2.1 Lesion size and site **37**
2.6.3 Initial functional severity **39**
2.6.3.1 Initial severity of aphasia **39**
2.6.3.2 Emotional status **39**
2.6.3.3 Cognitive impairment **40**
2.6.4 Rehabilitation of language impairments **43**
2.6.4.1 Intensity and timing of language rehabilitation **43**
2.6.5 Summary **44**
2.7 Current theoretical accounts of language rehabilitation **46**
2.8 Learning Vocabulary **51**
2.8.1 Word form **52**
2.8.2 Conceptual meaning of words **53**
2.8.3 Grammatical behaviour of words **54**
2.8.4 Summary and implications **55**
2.8.5 Current evidence for learning new vocabulary **56**
2.8.5.1 Healthy adults learning vocabulary **56**
2.8.5.2 Adults with memory impairment learning vocabulary **59**
2.8.5.3 Adults with aphasia learning vocabulary **61**
2.8.6 Summary of learning studies **63**
2.9 Considerations for investigating new vocabulary learning **65**
2.9.1 Stimuli **65**
2.9.2 Optimal learning techniques **66**
2.9.3 Method for recording and evaluating new learning **67**
2.10 Chapter summary **70**

Chapter 3 Preliminary Studies

3.1 Introduction **72**
3.2 Preliminary Study One **74**
3.2.1 Procedure **74**
3.2.1.1 Stimuli **74**

3.2.1.2 Initial training and assessment procedure **75**
3.2.1.3 Immediate recall **75**
3.2.1.4 Delayed recall **76**
3.2.1.5 Qualitative information **76**
3.2.1.6 Scoring system **77**
3.2.2 Results **77**
3.2.2.1 Immediate recall **77**
3.2.2.2 Delayed recall **79**
3.2.3 Learning strategies used by participants **80**
3.2.4 Discussion and implications **81**
3.3 Preliminary Study Two **83**
3.3.1 Procedure **83**
3.3.1.1 Stimuli **83**
3.3.1.2 Initial training and assessment procedure **83**
3.3.2 Results **84**
3.3.2.1 Immediate recall **84**
3.3.2.2 Delayed recall **86**
3.3.3 Discussion and implications **88**
3.4 Preliminary Study Three **90**
3.4.1 Procedure **90**
3.4.2 Results **90**
3.4.3 Discussion and implications **91**
3.5 Preliminary Study Four **92**
3.5.1 Procedure **92**
3.5.1.1 Initial training and assessment procedure **92**
3.5.2 Results **93**
3.5.3 Discussion **94**
3.6 Contribution of Preliminary Studies' findings to Main Investigation **95**
3.6.1 Stimuli properties **95**
3.6.1.1 Uniqueness of stimuli **95**

3.6.1.2 Number and type of items to be learnt **95**
3.6.2 Control issues **96**
3.6.3 Training procedure **96**
3.6.4 Assessment procedure **97**
3.7 Chapter summary **97**

Chapter 4 Pilot Studies: Finalisation of Methodology for the Main Investigation

4.1 Introduction **101**
4.2 Screening assessment procedure **102**
4.2.1 Evaluation of emotional well-being **102**
4.2.2 Screening of cognitive abilities **103**
4.2.2.1 The cognitive linguistic quick test (CLQT) **103**
4.2.2.2 Non-linguistic learning task **103**
4.2.3 Screening of language abilities **104**
4.2.3.1 Scoring system for language abilities **105**
4.3 Training session procedure **106**
4.3.1 Baseline measures **107**
4.3.2 Training procedure **107**
4.3.2.1 Training of stimuli: phonological information i.e. new word forms **108**
4.3.2.2 Training of stimuli: semantic information i.e. new word meanings **108**
4.3.2.3 Consolidation and rehearsal of learning – Independent learning **109**
4.3.3 Procedure for assessment of new learning **109**
4.3.3.1 Cold recall **110**
4.3.3.2 Lexical recognition task **111**
4.3.3.3 Syllable matching task **111**

4.3.3.4 Categorisation tasks **111**
4.3.3.5 Word-to-picture matching tasks **111**
4.3.3.6 Scoring system **112**
4.4 Pilot study one **113**
4.4.1 Participant details **113**
4.4.2 Results of P1's performance of screening assessments **113**
4.4.3 Results of P1's post-training assessment **114**
4.4.3.1 Immediate recall **114**
4.4.3.2 Delayed recall **115**
4.4.3.3 One month delayed recall **115**
4.4.3.4 Timing of sessions **116**
4.4.4 Methodological issues **117**
4.4.4.1 Presentation of stimuli **117**
4.4.4.2 Addition / amendment of materials **118**
4.4.4.3 Consolidation of learning **119**
4.4.5 Summary of pilot study one **120**
4.5 Pilot study two **121**
4.5.1 Participant details **121**
4.5.2 Results of P2's performance of screening assessments **122**
4.5.3 Results of P2's post-training assessments **123**
4.5.3.1 Immediate recall **123**
4.5.3.2 Delayed recall **124**
4.5.3.3 Timing of sessions **125**
4.5.4 Summary of pilot study two **125**
4.6 Pilot study three **126**
4.6.1 Participant details **126**
4.6.2 Training and assessment sessions **127**
4.6.3 Methodological issues **128**
4.6.4 Summary of pilot study three **128**
4.7 The methodology for the main investigation **130**

4.8 Chapter summary **132**

Chapter 5 The Main Investigation

5.1 Introduction **134**
5.2 Method **135**
5.2.1 Participant criteria and selection **135**
5.2.2 Procedure **137**
5.3 Main investigation findings **138**
5.3.1 Comparison of characteristics of learning between aphasic and normal populations **143**
5.4 Case series **145**
5.4.1 Individual profile structure **145**
5.4.2 Predictions of influencing factors on learning the new vocabulary **147**
5.4.2.1 Personal attributes **147**
5.4.2.2 Cognitive abilities and the capacity to learn **149**
5.4.2.3 Severity of aphasia **150**
5.4.2.4 Rehearsal and consolidation of learning **150**
5.5 Participant C1 **152**
5.5.1 Predictive factors for learning new vocabulary **152**
5.5.1.1 Personal attributes **153**
5.5.1.2 Cognitive abilities and the capacity to learn **153**
5.5.1.3 Severity of aphasia **153**
5.5.1.4 Rehearsal and consolidation of learning **155**
5.5.2 Demonstration of learning the new vocabulary **155**
5.5.2.1 Immediate recall **155**
5.5.2.2 Delayed recall **156**
5.5.2.3 Summary of new learning **156**
5.6 Participant P3 **157**
5.6.1 Predictive factors for learning new vocabulary **157**

5.6.1.1 Personal attributes **157**
5.6.1.2 Cognitive abilities and the capacity to learn **158**
5.6.1.3 Severity of aphasia **158**
5.6.1.4 Rehearsal and consolidation of learning **160**
5.6.2 Demonstration of learning the new vocabulary **160**
5.6.2.1 Immediate recall **160**
5.6.2.2 Delayed recall **161**
5.6.2.3 Summary of new learning **161**
5.7 Participant C2 **163**
5.7.1 Predictive factors for learning new vocabulary **163**
5.7.1.1 Personal attributes **164**
5.7.1.2 Cognitive abilities and the capacity to learn **164**
5.7.1.3 Severity of aphasia **164**
5.7.1.4 Rehearsal and consolidation of learning **166**
5.7.2 Demonstration of learning the new vocabulary **166**
5.7.2.1 Immediate recall **166**
5.7.2.2 Delayed recall **167**
5.7.2.3 Summary of new learning **167**
5.8 Participant C3 **169**
5.8.1 Predictive factors for learning new vocabulary **169**
5.8.1.1 Personal attributes **170**
5.8.1.2 Cognitive abilities and the capacity to learn **170**
5.8.1.3 Severity of aphasia **170**
5.8.1.4 Rehearsal and consolidation of learning **172**
5.8.2 Demonstration of learning the new vocabulary **172**
5.8.2.1 Immediate recall **172**
5.8.2.2 Delayed recall **173**
5.8.2.3 Summary of new learning **173**
5.9 Participant C4 **175**
5.9.1 Predictive factors for learning new vocabulary **175**

5.9.1.1 Personal attributes **176**
5.9.1.2 Cognitive abilities and the capacity to learn **176**
5.9.1.3 Severity of aphasia **176**
5.9.1.4 Rehearsal and consolidation of learning **178**
5.9.2 Demonstration of learning the new vocabulary **178**
5.9.2.1 Immediate recall **178**
5.9.2.2 Delayed recall **179**
5.9.2.3 Summary of new learning **180**
5.10 Participant C5 **181**
5.10.1 Predictive factors for learning new vocabulary **181**
5.10.1.1 Personal attributes **182**
5.10.1.2 Cognitive abilities and the capacity to learn **182**
5.10.1.3 Severity of aphasia **183**
5.10.1.4 Rehearsal and consolidation of learning **184**
5.10.2 Demonstration of learning the new vocabulary **184**
5.10.2.1 Immediate recall **184**
5.10.2.2 Delayed recall **185**
5.10.2.3 Summary of new learning **186**
5.11 Participant C6 **187**
5.11.1 Predictive factors for learning new vocabulary **187**
5.11.1.1 Personal attributes **188**
5.11.1.2 Cognitive abilities and the capacity to learn **188**
5.11.1.3 Severity of aphasia **188**
5.11.1.4 Rehearsal and consolidation of learning **190**
5.11.2 Demonstration of learning the new vocabulary **190**
5.11.2.1 Immediate recall **190**
5.11.2.2 Delayed recall **191**
5.11.2.3 Summary of new learning **191**
5.12 Participant C7 **192**
5.12.1 Predictive factors for learning new vocabulary **192**

5.12.1.1 Personal attributes **193**
5.12.1.2 Cognitive abilities and the capacity to learn **193**
5.12.1.3 Severity of aphasia **193**
5.12.1.4 Rehearsal and consolidation of learning **195**
5.12.2 Demonstration of learning the new vocabulary **195**
5.12.2.1 Immediate recall **195**
5.12.2.2 Delayed recall **196**
5.12.2.3 Summary of new learning **196**
5.13 Participant C8 **197**
5.13.1 Predictive factors for learning new vocabulary **197**
5.13.1.1 Personal attributes **198**
5.13.1.2 Cognitive abilities and the capacity to learn **198**
5.13.1.3 Severity of aphasia **198**
5.13.1.4 Rehearsal and consolidation of learning **200**
5.13.2 Demonstration of learning the new vocabulary **200**
5.13.2.1 Immediate recall **200**
5.13.2.2 Delayed recall **201**
5.13.2.3 Summary of new learning **201**
5.14 Participant C9 **202**
5.14.1 Predictive factors for learning new vocabulary **202**
5.14.1.1 Personal attributes **203**
5.14.1.2 Cognitive abilities and the capacity to learn **203**
5.14.1.3 Severity of aphasia **203**
5.14.1.4 Rehearsal and consolidation of learning **205**
5.14.2 Demonstration of learning the new vocabulary **205**
5.14.2.1 Immediate recall **205**
5.14.2.2 Delayed recall **206**
5.14.2.3 Summary of new learning **206**
5.15 Participant C10 **207**
5.15.1 Predictive factors for learning new vocabulary **207**

5.15.1.1 Personal attributes **208**
5.15.1.2 Cognitive abilities and the capacity to learn **208**
5.15.1.3 Severity of aphasia **208**
5.15.1.4 Rehearsal and consolidation of learning **210**
5.15.2 Demonstration of learning the new vocabulary **210**
5.15.2.1 Immediate recall **210**
5.15.2.2 Summary of new learning **211**
5.16 Participant C11 **212**
5.16.1 Predictive factors for learning new vocabulary **212**
5.16.1.1 Personal attributes **213**
5.16.1.2 Cognitive abilities and the capacity to learn **213**
5.16.1.3 Severity of aphasia **213**
5.16.1.4 Rehearsal and consolidation of learning **215**
5.16.2 Demonstration of learning the new vocabulary **215**
5.16.2.1 Immediate recall **215**
5.16.2.2 Summary of new learning **216**
5.17 Summary **217**
5.18 Factors affecting the learning of new vocabulary **219**
5.18.1 Hierarchical cluster analyses **220**
5.18.2 Statistical correlations between learning performance and various participant factors **224**
5.18.2.1 Personal attributes **225**
5.18.2.2 Cognitive abilities **227**
5.18.2.3 Language ability **228**
5.18.2.4 Learning strategies **229**
5.18.3 Aspects of the methodology in relation to participant performance **230**
5.18.3.1 Reliability of learning performance **230**
5.18.3.2 Learning performance in relation to individual stimuli **231**

5.18.3.3 Learning performance in relation to learning assessment tasks **232**
5.19 Chapter summary **233**

Chapter 6 Discussion of Findings

6.1 Introduction **235**
6.2 Discussion of findings in relation to the main research question **236**
6.3 Factors affecting the learning of new vocabulary **238**
6.3.1 Personal attributes **239**
6.3.1.1 The impact of age on the learning of new vocabulary **240**
6.3.1.2 The impact of education on the learning of new vocabulary **241**
6.3.1.3 The impact of cognitive reserve on the learning of new vocabulary **242**
6.3.1.4 The impact of emotional status on the learning of new vocabulary **244**
6.3.1.5 The impact of stage of recovery from stroke on the learning of new vocabulary **246**
6.3.1.6 Summary **247**
6.3.2 Biological limitations **249**
6.3.3 Cognitive abilities and the capacity to learn **249**
6.3.3.1 The impact of attention on the learning of new vocabulary **250**
6.3.3.2 The impact of memory on the learning of new vocabulary **252**
6.3.3.3 The impact of executive functions on the learning of new vocabulary **253**
6.3.3.4 The impact of non-linguistic learning on the learning of new vocabulary **254**

6.3.3.5 The impact of clock drawing task on the learning of new vocabulary **255**
6.3.3.6 Summary **256**
6.3.4 Language ability **257**
6.3.4.1 Pre-training language screening assessments **258**
6.3.4.2 Main investigation language assessments **259**
6.3.5 Learning strategies **260**
6.3.6 Summary **262**
6.4 Evaluation of the methodology **263**
6.4.1 Participants **263**
6.4.2 Methodology **264**
6.4.2.1 Nature and development of the stimuli **264**
6.4.2.2 Development of the methodology **265**
6.5 The effectiveness of the cognitive neuropsychology model in supporting the main investigation and its usefulness as a tool in learning studies **266**
6.5.1 Assess and evaluate the severity of aphasia **266**
6.5.2 Support the methodology for learning procedure **267**
6.5.3 Measurement of learning **268**
6.5.3.1 Baseline measures **268**
6.5.3.2 Facilitate the demonstration and measurement of new learning **268**
6.5.4 Facilitate predictions for new learning by participants **269**
6.5.4.1 Spoken demonstration of learning **270**
6.5.4.2 Written demonstration of learning **271**
6.5.4.3 Qualitative characteristics of learning **271**
6.5.5 Some support and criticisms of the cognitive neuropsychological model **272**
6.5.6 Summary **274**
6.6 Clinical relevance **275**

6.6.1 New learning **276**
6.6.2 Learning and aphasia rehabilitation **277**
6.6.3 Prognostic factors **279**
6.7 Evaluation of the investigation **282**
6.8 Suggestions for future research **283**
6.9 Summary and conclusions **286**

References **290**

Appendices

2.1	Main representative processes accessed according to the cognitive neuropsychology model	**305**
3.1	Preliminary Study One - Novel stimuli	**306**
3.2	Preliminary Study One - Training procedure script	**307**
3.3	Preliminary Study One - Qualitative data responses for the procedural questions	**309**
3.4a	Preliminary Study Two - Stimuli used for Group B	**310**
3.4b	Preliminary Study Two - Stimuli used for Group A	**310**
3.5	Preliminary Study Two - Qualitative data responses for the procedural questions	**311**
3.6	Stimuli used for the main investigation	**312**
4.1	Methods of learning new information	**316**
4.2	Hospital anxiety and depression scale (HADs)	**318**
4.3	Cognitive Linguistic Quick Test – severity ratings and scores	**321**
4.4	Non-linguistic learning task – stepping-stone route	**322**
4.5	Language screening assessment	**324**
4.6	Familiar, trained and untrained non-word stimuli for each training session	**326**
4.7	Practice assessment tasks provided during the independent learning time	**327**
4.8	Examples of written and picture details of creatures	**328**
5.1	Participant information sheet for main investigation	**329**
5.2	Participant consent form	**330**
5.3	Narrations of Cinderella story by participants	**331**
5.4	Hierarchical Cluster Analyses	**335**
5.5	Group correlation scatterplots for immediate and delayed recall	**341**
5.6	Total recall of stimuli for immediate and delayed recall (new words)	**345**
5.7	Total recall of tasks for immediate and delayed recall (assessments)	**346**

Tables

3.1	Preliminary study one - Total raw scores for immediate recall	**78**
3.2	Preliminary study one – Total raw scores for delayed recall	**79**
3.3	Preliminary study one - Examples of learning strategies used as reported by participants	**80**
3.4	Preliminary study two – Total raw scores for immediate recall	**84**
3.5	Preliminary study two – Total raw scores for delayed recall	**87**
3.6	Preliminary study four – Some participant suggestions as to the names and skills of the stimuli	**93**
3.7	Preliminary study four – Performance of participants on assessment tasks	**94**
4.1	Cognitive Neuropsychology Pathways accessed by new vocabulary training tasks	**106**
4.2	Cognitive Neuropsychology Pathways accessed by new vocabulary assessment tasks	**110**
4.3	Pilot study one – Total raw and percentage correct scores for immediate recall by P1	**114**
4.4	Pilot study one – Total raw and percentage correct scores for one month delayed recall by P1	**116**
4.5	Pilot study one – Timing of all sessions for P1	**116**
4.6	Pilot study two – Raw scores and severity rating for CLQT by P2	**122**
4.7	Pilot study two – Raw and percentage correct scores for P2's language screening assessments	**122**
4.8	Pilot study two – Total raw and percentage correct scores for immediate recall by P2	**123**
4.9	Pilot study two – Total raw and percentage correct scores for delayed recall by P2	**124**
4.10	Pilot study three – Timing of all sessions for P3	**127**
5.1	Raw and percentage scores for immediate recall tasks	**139**

5.2	Raw and percentage scores for non-verbal assessment tasks for immediate recall	**140**
5.3	Raw and percentage scores for delayed recall tasks	**141**
5.4	Ranking and performance of learning by participants for immediate and delayed recall	**142**
5.5	Characteristics of error types unique to the aphasic participants	**144**
5.6	Example of participant profile table	**145**
5.7	Glossary and legend for following case series tables	**151**
5.8	C1's personal, medical, language and cognitive data	**152**
5.9	C1's detailed performance on learning new vocabulary	**155**
5.10	P3's personal, medical, language and cognitive data	**157**
5.11	P3's detailed performance on learning new vocabulary	**161**
5.12	C2's personal, medical, language and cognitive data	**163**
5.13	C2's detailed performance on learning new vocabulary	**167**
5.14	C3's personal, medical, language and cognitive data	**169**
5.15	C3's detailed performance on learning new vocabulary	**173**
5.16	C4's personal, medical, language and cognitive data	**175**
5.17	C4's detailed performance on learning new vocabulary	**179**
5.18	C5's personal, medical, language and cognitive data	**181**
5.19	C5's detailed performance on learning new vocabulary	**185**
5.20	C6's personal, medical, language and cognitive data	**187**
5.21	C6's detailed performance on learning new vocabulary	**190**
5.22	C7's personal, medical, language and cognitive data	**192**
5.23	C7's detailed performance on learning new vocabulary	**195**
5.24	C8's personal, medical, language and cognitive data	**197**
5.25	C8's detailed performance on learning new vocabulary	**201**
5.26	C9's personal, medical, language and cognitive data	**202**
5.27	C9's detailed performance on learning new vocabulary	**206**
5.28	C10's personal, medical, language and cognitive data	**207**
5.29	C10's detailed performance on learning new vocabulary	**211**

5.30	C11's personal, medical, language and cognitive data	**212**
5.31	C11's detailed performance on learning new vocabulary	**216**
5.32	Hierarchical cluster analyses - comparison of various clusters with initial immediate recall score groupings	**222**
5.33	Correlation co-efficients: IR~ personal attributes (n=11)	**226**
5.34	Correlation co-efficients: DR~ personal attributes (n=10)	**226**
5.35	Correlation co-efficients: IR~ cognitive screening scores (n=11)	**228**
5.36	Correlation co-efficients: DR~ cognitive screening scores (n=10)	**228**
5.37	Correlation co-efficients: IR~ aphasia screening scores (n=11)	**229**
5.38	Correlation co-efficients: DR~ aphasia screening scores (n=10)	**229**
5.39	Correlation co-efficients: IR ~ independent learning time (n=11)	**230**
5.40	Correlation co-efficients: DR ~ independent learning time (n=10)	**230**
5.41	Correlation co-efficients: IR ~ reliability of performance for each training session	**230**
5.42	Correlation co-efficients: DR~ reliability of performance for each training sessions	**231**

Figures

2i	Cognitive neuropsychology model of single word processing	**68**
4i	Support of cognitive neuropsychological model for learning procedure	**131**
5i	Final methodology for the main investigation	**137**
5ii	Representation of C1’s single word processing	**154**
5iii	Representation of P3’s single word processing	**159**
5iv	Representation of C2’s single word processing	**165**
5v	Representation of C3’s single word processing	**171**
5vi	Representation of C4’s single word processing	**177**
5vii	Representation of C5’s single word processing	**183**
5viii	Representation of C6’s single word processing	**189**
5ix	Representation of C7’s single word processing	**194**
5x	Representation of C8’s single word processing	**199**
5xi	Representation of C9’s single word processing	**204**
5xii	Representation of C10’s single word processing	**209**
5xiii	Representation of C11’s single word processing	**214**
5xiv	Hierarchical cluster analysis	**220**

Graphs

3.1	Comparison of number of items learned by participants in Group A from immediate recall (written) preliminary studies one and two	**85**
3.2	Comparison of number of items learned by participants in Group B from immediate recall (written) preliminary studies one and two	**86**

Chapter 1 Introduction to investigation

Many professionals are involved in the rehabilitation of post-stroke individuals both at the acute and chronic phases of their stroke, including allied health professionals such as physiotherapists, occupational therapists and speech and language therapists. Their aim in rehabilitation is to return a person to their highest functioning potential as would be expected for their age, occupation and gender roles (Hinckley, 1998). The following evidence indicates that the incidence of people sustaining brain injury as a result of stroke is increasing yearly, particularly within the younger population. The prevalence of stroke is also increasing as more people are surviving stroke. Petheram and Enderby (2001) reported an increase in the population referred to a group of 11 speech and language therapy providers between 1987-1995. The most significant proportional increase in the caseload is related to referrals associated with stroke. These have increased from 534 (22.7%) in 1987 to 2098 (32%) in 1995 (Petheram and Enderby, 2001). While referrals for swallowing difficulties have increased during this time (0.94% of referrals in 1987 and 20.6% in 1995) referrals for aphasia have doubled in this same period (Enderby and Petheram, 2002; Petheram and Enderby, 2001). This increase in stroke referral is not particular to Britain. In an urban population of 250,000 in Sweden, stroke incidence increased between 1989 and 1998 while case fatality decreased with improved short and long-term survival following stroke (Pessah-Rasmussen, Engström, Jerntorp and Janzon, 2003). Data from three national health surveys in the United States have paralleled this trend of demonstrating consistent improvement of survival following stroke during the 1970s and 1980s. The number of stroke deaths among the population aged 25 to 74 years consistently declined between 1971 and 1994 from 81,000 to 44,000, a decrease of 47%. The prevalence of stroke in the United States increased by 30% between 1973 and 1991 and over the same period, the number of stroke survivors younger than 75 years increased by 930,000 (Muntner, Garrett, Klag, and Coresh, 2002).

Younger people who are having and surviving strokes may present with expectations for quality of life quite different from those of more elderly people. They may desire to return to employment or retrain for a different career, perhaps continue or undertake personal development in the form of life long learning in further education or leisure pursuits alongside their peers. All of these activities require the person to learn new information following their stroke. The question of the potential of the damaged brain to learn new information has not yet been adequately addressed. This thesis examines, in particular, new vocabulary learning for those people who have persistent language difficulties following a stroke.

The main aim for this research was to address the question of whether young adults with post-stroke aphasia can learn new vocabulary. As this was the first investigation into the learning of new vocabulary by post-stroke adults with aphasia, the stimuli and methodology had to be developed. The investigation began with preliminary studies in which novel stimuli (new words with new meanings) were developed and evaluated for use in the main investigation. Next, investigation of the learning abilities of 75 adults with no history of brain injury and the strategies that they used to learn the new words contributed to the development of the learning procedure for the participants with aphasia. The completed methodology was evaluated with one adult with no cognitive or language impairments as well as with post-stroke adults with and without aphasia. The main investigation involved a case series of 12 post-stroke individuals (six male and six female) with a range of severity of aphasia to ascertain if young adults could learn new vocabulary despite having language impairments following a stroke. The individual performance of each person was evaluated and group analyses were undertaken to determine if predictions could be made regarding the ability of adults with post-stroke aphasia to learn new vocabulary. An analysis of the potential factors that could have facilitated or hindered this new learning was also carried out.

The content and layout of the thesis are as follows. Focussing on a review of the literature, Chapter 2 presents a working definition of aphasia and comments on the impact of aphasia on an individual's quality of life. Learning by adults with no history of brain injury is discussed including the attributes that give optimal learning. Evidence of the potential of the damaged brain to recover and learn is also presented in this chapter and factors that may influence this learning capacity are highlighted. These factors include personal attributes (e.g. age and education), cognitive abilities (e.g. attention, executive function and memory), as well as language (e.g. spoken and written comprehension and expression). Chapter 3 reports on the development of the methodology and describes four preliminary studies that examined how adults without cognitive or language difficulties learned the new vocabulary. The strategies that these participants used to learn the new vocabulary were analysed with a view to informing the main investigation participants as to the best learning methods. These preliminary studies informed the final methodology of the main investigation which is discussed in detail in Chapter 4 along with its development with pilot study adults (normal language and cognition, post-stroke non-aphasic, and post-stroke aphasic). Chapter 5 presents the findings of the research question, i.e. can adults with post-stroke aphasia learn new vocabulary despite language impairment? Profiles of the 12 main investigation participants with aphasia who present with a wide range of language difficulties are also presented in this chapter as well as the results of their performance in learning the new vocabulary. Chapter 5 also investigates if predictions can be made about the wider aphasic population that may inform the professionals involved in their rehabilitation. Chapter 6 discusses and evaluates the findings of the investigation with reference to the current literature and discusses the implications of the individual learning performances for the participants themselves, the aphasic population as a whole and those professionals involved in their rehabilitation. Suggestions for further research are also discussed.

Chapter 2 Review of the literature and investigation considerations

2.1 INTRODUCTION

As Chapter 1 indicates, the incidence of stroke is increasing among the younger population (<65 years) and due to advanced medical technology more of these people are surviving. It is difficult to ascertain how many people continue to present with aphasia, as statistics mainly report incidence and prevalence of stroke rather than the residual disability of aphasia. Parr, Byng, Gilpin and Ireland (1997) state that in the United Kingdom alone at least 20,000 people become aphasic every year. If this population has expectations for a quality of life that includes new learning, such as aspects of career change, further education and new leisure activities alongside their peers, then the potential of their damaged brain to undertake these endeavours must be investigated.

The term 'aphasia' will be defined in this chapter and the impact that it has on the lives of stroke survivors who continue to have language difficulties will be described. The literature pertaining to the impact of aphasia on an individual's quality of life will also be discussed. Evidence for the efficacy of aphasia rehabilitation and the resultant cortical plasticity will be reported and factors considered to influence the recovery of aphasia will be discussed. Current theories of therapy are reported and the potential contribution of theories of learning to a theory of aphasia rehabilitation is discussed. Evidence (biological and behavioural) for new learning by adults who have no history of brain injury will be evaluated. The reported knowledge regarding the potential of the damaged brain to demonstrate new learning will be discussed and predictions will be made regarding the potential of people with aphasia to learn new vocabulary. Finally, considerations for an investigation into the potential of individuals with aphasia to learn new vocabulary are discussed.

2.2 WHAT IS APHASIA?

> 'Aphasia can be seen as a disorder of communication leading to a disorder of person' (Sarno, 1993; 323).

While the underlying assumptions about who is and who is not aphasic began about 125 years ago there is still little agreement within the scientific community about the precise characteristics that define aphasia (McNeill and Pratt, 2001). Many publications relating to aphasia research are difficult to interpret because the characteristics of the participants with aphasia are not specified (McNeill and Pratt, 2001). Therefore any findings are less meaningful to the reader if it is not clear precisely which population the results refer to thus preventing generalisation to other relevant populations. It is therefore important to define what characterises the aphasic population participating in this investigation. The term 'aphasia' is used to describe the impairment to the human language system following brain damage. The most common cause of aphasia is cerebrovascular accident (CVA), commonly known as stroke, mainly to the left hemisphere where the main language function of the brain is situated for right-handed people. About one third of all people who experience a stroke develop aphasia (Parr et al., 1997).

The aphasic population is heterogeneous in nature and any number and variations of the characteristics of aphasia can affect individuals. Therefore aphasia is variable and different for each individual. Aphasia can affect some or all modalities of language processing: expression and comprehension of speech, reading and writing, gesture and communication (Code and Herrmann, 2003). Aphasia also varies in severity. An individual may have occasional word-finding difficulties generating pauses or sporadic errors of speech or writing. Others being more severely affected may be unable to put their ideas and intentions into spoken and / or written language, having no intelligible communication. Yet others may have difficulty in forming grammatical sentences. As aphasia also affects the understanding of language it can affect an individual's ability to understand complex sentences or impede the ability of a person to understand even simple sentences or spoken or written single words. Aphasia can also affect the ability to understand and use various methods of communication other than speech, for example, gesture (Parr et al., 1997). The severity of aphasia can also change over time as one area of language may resolve while others remain impaired. This severity can also fluctuate from one day to the next where a person may have many word-finding difficulties one day and on another their speech may be more fluent (Parr et al., 1997). Society considers the ability to communicate through speech and writing to be signs of intelligence (Parr et al., 1997). However, while language difficulties that arise as a result of aphasia may hinder a person understanding or expressing in the spoken and / or written medium it does not affect their ability to think, feel, remember and plan, and therefore intelligence is not considered to be affected by aphasia (Parr et al., 1997).

Aphasia can occur transiently where a person acquires language difficulties, for example as a result of epilepsy, migraine or transient ischaemic attacks (TIAs), but this resolves back to their normal baseline or within normal limits in a matter of hours or days (McNeil and Pratt, 2001). Cerebral tumours can also result in aphasia (Parr et al., 1997) as can some traumatic brain injury, although this injury often affects the social uses of language (McDonald, Togher and Code, 1999). The definition of aphasia assumed by this investigation encompasses acquired language impairment and excludes other communication difficulties attributable to sensory loss (such as acquired deafness), confusion, dementia, or speech difficulties due to muscular weakness or dysfunction such as dysarthria (Darley, 1982). The population participating in this investigation consisted of people who had acquired language impairment (aphasia) as a direct result of a stroke. This type of brain injury was chosen for a number of reasons. CVA is mainly 'focal' rather than 'diffuse' in nature and from a specific source (thrombosis or haemorrhage). Also aphasia resulting from a CVA is not transient in nature (as with TIAs) but rather is relatively stable and consists of a more permanent focal lesion that has a slow rate of recovery and in most cases leaves the individual with residual communication impairment.

2.2.1 Recovery from aphasia

While the course of recovery from aphasia is different for every individual, functional imaging studies have indicated that there are two mechanisms involved in the process, namely, regression from diaschisis and brain plasticity (Cappa, 2000). Hillis and Heidler's (2002) description of the recovery from stroke incorporates further stages in the healing process. According to their view, occasional and rapid resolution of language impairment occurs during the first few days following a stroke irrespective of severity of the brain trauma. This acute stage involves the restoration of function to impaired neural tissue as a result of swelling reduction and restoration of blood flow to areas that are receiving enough blood for cell survival but not enough to function. It is at this stage that any blood leakage, which has a toxic effect on brain tissue, is reabsorbed into the bloodstream. The second stage of the recovery process (subacute) begins within days of having the stroke and can continue for weeks, months or even years following onset as the brain reorganises its damaged structure / function interactions. A further third stage of the recovery process involves creating new neural pathways to areas that were disconnected from parts of the brain as a result of the stroke (Hillis and Heidler, 2000; Seitz, Azari, Knorr, Binkofski, Herzog and Freund, 1999). Following these acute stages the chronic stage involves learning compensatory strategies in order to communicate more effectively, for example using gesture or writing where language output is unintelligible to the listener due to neologisms in jargon. All of these stages of recovery are thought to overlap, for example one language function might be recovering at one stage while another language function may be at another. Although some people make a good recovery from aphasia many continue to experience significant communication difficulties for the rest of their lives (Code and Herrmann, 2003; McArthur, Frederick, Hartley, Yardley, Booth and Armstrong, 2002; Hillis and Heidler, 2000). So what is the impact of aphasia on an individual's quality of life?

2.3 THE IMPACT OF APHASIA

While many people associate the idea of disability with physical or sensory impairments (for example, people who use wheelchairs to mobilise) communication impairment such as aphasia cannot be seen. Aphasia therefore does not fit in easily with society's perception of disability (Parr et al., 1997). Despite this perception the literature reports that aphasia has a large impact on a person's life, turning ordinary everyday communicative situations into a struggle in understanding what is being communicated to them and being understood by others (Doesborgh, van de Sandt-Koenderman, Dippel, van Harskamp, Koudstaal and Visch-Brink, 2002).

> 'When I am with others and they speak to me I have to understand what they say right away, otherwise it is too late – the subject of discussion will have gone onto something else' (Christensen, 1997; 730)
>
> 'I was mad. I was mad in here that it wouldn't come out – when I did try to say something um….an it all come out….well gobbledegook…. em…. an I knew what I was going to say but I couldn't say it' (Parr et al., 1997; 15)
>
> 'In my head I can talk, only the mouth will not' (Christensen, 1997; 733)

Sarno (1993) reminds us that the use of a speech code in communication exists only in humans and aphasia therefore assaults that very component which defines our humanness. Code and Herrmann (2003) reiterate the importance of intact communication abilities in developing and maintaining social relationships and state that the experience of aphasia results in a sudden and devastating incapacity to participate in many day-to-day activities. Aphasia impacts upon leisure, occupational, social and family activities (Code and Herrmann, 2003; Gainotti, 1997), which reflect a person's quality of life. Sarno (1997) states that at least four domains are assessed when a person's quality of life is considered. These include emotional and social functioning, daily living activities and the ability to actively engage in pleasurable pursuits. Perceptions of lifestyle satisfaction are an important component of quality of life and handicap measurements (Hinckley, 1998). In contrast to studies for the general stroke population, Hinckley (1998) reports that hemiparesis did not predict lifestyle satisfaction for the aphasic population. She suggests that communication impairment could have a stronger effect on quality of life perception than persisting motor impairment within the aphasic population. Le Dorze and Brassard (1995) concur stating that language disabilities are the major cause of handicap in society as they negatively impact upon all communication situations, where interpersonal relationships are changed and the person is left feeling stigmatised with a loss of personal autonomy. Overall, a person's ability to communicate and in particular a person with aphasia's communication predicted their psychological well-being and social wealth.

However, not all data agree with these reports and some indicate that aspects other than the severity of their language affect the person with aphasia's quality of life (Ross and Wertz, 2003). One study evaluated 24 facets proposed by the World Health Organisation Quality of Life Group (1996), which best differentiated the aspects that affect the quality of life for individuals with aphasia (n=18) and non-aphasic individuals (n=18) (Ross and Wertz, 2003). This study noted that there were three areas that affected the person with aphasia's quality of life. Firstly a person's level of independence and their ability to carry out their daily activities, to be mobile and to return to employment were priorities for these participants. Secondly, social relationships were impacted upon where participants prioritised having satisfaction with support from their friends and also in their intimate relationships. Finally, in the environmental domain the importance of information accessibility, health services, and transportation were a priority for those participants with aphasia. These results concur with previous reports of loss of independence (Herrmann and Wallesch, 1990) and the inability to work being priorities for people with aphasia, other than their communication disability (Herrmann and Wallesch, 1990; Kinsella and Duffy, 1979; Sarno, 1993). However, the following discussions will reveal that many of the priorities mentioned above are impacted upon as a direct result of having impaired communication abilities, where aphasic individuals may even settle for a more limited quality of life because of their expectations of living with a disability (Ellis-Hill and Horn, 2000).

It is not only the person with aphasia whose life experiences change following their stroke. Therefore, the review of the literature reporting the impact of communication impairment on a person with aphasia will also encompass the negative impact on family and friends within their interpersonal relationships and communication with the person with aphasia, their increased responsibilities (in many cases) and adaptations to their work and leisure activities. Four areas of quality of life will now be explored – the emotional impact of acquiring and living with aphasia, the adaptation of social functioning as a direct result of a communication impairment, the impact of aphasia on the family unit, and its affect on their ability to actively engage in pleasurable activities.

2.3.1 Emotional impact of aphasia

Keppel and Crowe (2000) state that the collective effects of sudden physical and cognitive impairment coupled with a slow recovery process commonly results in some level of emotional disturbance. These emotional effects consequently influence quality of life for people with aphasia, influenced by their own and society's attitudes towards disability and an awareness of the implications of having aphasia on their quality of life (Gainotti, 1997). In fact for a young person the most devastating consequences of a stroke may be its effect on their perception of self (Keppel and Crowe, 2000), resulting in symptoms such as depression during both the acute and the chronic phases of stroke recovery (Robinson, 2003; Spalletta, Guida, De Angelis and Caltagirone, 2002; Kauhanen, Korpelainen, Hiltunen, Brusin, Mononen, Maatta, Nieminen, Sotaniemi and Myllyla 1999; Kotila, Numminen, Waltimo and Kaste, 1998; Astrom, Adolfsson and Asplund, 1993; Sarno, 1993). Robinson (2003) observed that over the past 10 years studies have investigated the prevalence of post-stroke depression and found that it occurs in approximately 10% (in a 12-month period) in the general population, whereas post-stroke depression was significantly higher at 18-20%. Spalletta et al.'s (2002) study identified that 58% of 153 people with aphasia had post-stroke depression following their first stroke.

Code and Herrmann (2003) state that there is converging evidence of an organic aetiology for post-stroke depression as a direct result of the brain injury (especially at the post-acute stage). In the chronic stage of the recovery process the prevalence of depression increases. This may be due to the fact that immediately post-stroke people are unaware of the extent of the impact of their stroke until they face the difficulty functioning with everyday activities (Code and Herrmann, 2003; Kauhanen et al. 1999) and the return to their pre-stroke environment may highlight an individual's degree of loss of function and independence (Hopman and Verner, 2003). Depression is considered to be a natural reaction to the loss of abilities caused by the stroke where a person realises the sudden and perhaps permanent limitations to their quality of life. This is equated to the natural grieving process (Code and Herrmann, 2003; Hinckley, 1998, Lazarus, 1993) incorporating denial, frustration, depression and finally acceptance (Herrmann, 1997). This stage of depression is seen as necessary to emotional recovery and must be worked through before acceptance can be achieved. Kauhanen et al. (1999) state that the severely debilitating condition of aphasia may contribute to the severity and persistence of depression in people following a stroke.

While the emotional state of a person impacts upon their quality of life it also significantly impacts upon their motivation, physical performance and cognitive and language processing (Beblo, Baumann, Bogerts, Wallesch and Herrmann, 1999). It is generally accepted that people with positive mood states respond better to rehabilitation than those who are depressed. Positive mood and well-being increase motivation and language and cognitive performance (Beblo et al., 1999). With the passing of time and the commencement of the psychological healing process individuals have to face the problems of reintegrating themselves into their social and community networks (Code, 2003). As with other areas of their lives aphasia impacts upon the social functioning of an individual with residual language difficulties and will now be addressed.

2.3.2 Social functioning with aphasia

Social functioning involves participation in an individual's community in terms of family relationships and role change, employment and social relationships (Sarno, 1997) and is important in the development and maintenance of self-worth, social validity, autonomy and perceived life satisfaction (Frattali, 1998). Code and Herrmann (2003) stress the importance of 'intact' communication in the development and maintenance of social relationships. Our own perceptions of our social interactions determine our personal experience of quality of life

(Code, Hemsley and Herrmann, 1999). The ability to return to work is an important issue for many stroke survivors (Bryan, Jordan, Lock, Maxim, O'Kelly and Gambrell, 2003; Code and Herrmann, 2003). Dawson and Chipman (1995) state that demographic factors such as age, gender or education have not yet been thoroughly investigated in determining the various factors that contribute to adults with aphasia returning or not returning to work. However Bryan et al. (2003) collated information from 672 young stroke survivors (mean age = 48 years) and examined the factors affecting the return to work for these individuals with aphasia. While 503 (75%) people stated that they had wanted to return to employment the actual number who returned to work was 211 (42%). Among some of the reasons respondents gave for not returning to work were being forced to retire by their employer (n=43), being unable to meet the expectations of their job (n=70) and 144 people could no longer perform their previous job. Some of the obstacles to returning to work following a stroke reported by the participants included memory difficulties, the ability to process a large amount of information and language difficulties (Bryan et al., 2003; Garcia, Barrette and Laroche, 2000). Hinckley (2002) advises that while the severity of aphasia impairment is not necessarily related to returning to work following a stroke, the limited evidence for return to employment for people with aphasia does not compare favourably with employment statistics for survivors of stroke in general. The focus on communication skills within the employment sector therefore forms a barrier for people with aphasia. Garcia et al. (2000) concur stating that the present market for employment is steering away from industrial jobs to more service delivery positions where employees are required to communicate clearly and efficiently within group situations. However barriers exist not just within the workplace but also arise in the one-to-one relationships between the person with aphasia and their family and friends. The impact on the family unit will now be explored.

2.3.3 Impact of aphasia on the family unit

Family members experience difficulties dealing with the various changes that occur following a stroke (Sarno, 1993) with communication reported as a severe problem more often in the marriages of people with aphasia than non-aphasic individuals (Artes and Hoopes, 1976; Kinsella and Duffy, 1979). Effective inter-personal communication helps to maintain relationships within the family unit and family members report that they have difficulty understanding their relative's message as the aphasia may prevent the individual providing enough information to be understood. Others find themselves in the role of translator-interpreter in social situations (Michallet, Tetreauet and Le Dorze, 2003). It is also reported that individual members of the family often distance themselves from the person with aphasia, in particular their children (Michallet et al., 2003). The practicalities within a family unit also change. Many agreements regarding roles (e.g. bread winner) and responsibilities (e.g. finances or social organiser) in the family no longer apply, resulting in major disruption to the family unit as a whole (Sarno, 1993). Additionally, family members may take on the role of caregiver. This involves the reorganisation of their day and in many cases their lives in order to prioritise the needs of their relative (Michallet et al., 2003). The changed attitude of carers/spouses towards their stroke-affected partner also has an important influence on intimacy (Keppel and Crowe, 2000) and the lack of communication may also reduce the ability to deal with any interpersonal relationship problems. Although the responses of family members to the impact of stroke and residual disabilities are varied, the most frequently observed reactions consist of minor mental health disorders (anxiety, guilt, fatigue and depression) (Michallet et al., 2003). Kotila et al., (1998) investigated the incidence and severity of depression in people following stroke as well as their closest relative who was also their main caregiver. They found that depression was common amongst these carers and there was no difference in frequency or severity of depression between post-stroke individuals and their caregivers. This depression has been observed to persist and not decrease at one-year follow-up

(Kotila et al., 1998; Anderson, Linto, Stewart-Wynne, 1995) compared to a control group consisting of people with diseases other than stroke (Carnwath and Johnson, 1987) and in one study was found to increase over a three year period (Carnwath and Johnson, 1987). While the impact of aphasia affects the dynamics of the family unit it also has consequences for pursuing pleasurable activities and hobbies that both the person with aphasia and their spouse /family engaged in prior to the stroke. The effect that language difficulties have on such quality of life activities will now be considered.

2.3.4 Active engagement in pleasurable activities with aphasia

In many cases prior to a stroke the person with aphasia and their spouse/ family and friends spent time together and had common hobbies and interests. Michallet et al. (2003) state that the increased responsibilities of the family members (causing fatigue) and the substantial increase in time invested in day-to-day activities may reduce the time or energy levels to pursue pleasurable activities. The extent to which aphasia affects a person's ability to continue to engage in those leisure activities enjoyed prior to their stroke largely depends upon the type of leisure pursuits, particularly where the activity was communication related. Additionally, as previously mentioned (see section 2.3.3) some family members are required to take on the role of translator and / or interpreter in social situations and many people report that this disrupts their social relationships and subsequently tend to avoid these contacts with others (Michallet et al., 2003).

2.3.5 Summary

As discussed the quality of a person's life changes as a direct result of acquiring aphasia following a stroke. Apart from the actual difficulties understanding and expressing language, communication impairment also impacts upon a person's emotional well-being, their social functioning and their family unit. The emotional impact of living with aphasia has been discussed (see section 2.3.1) affecting all facets of a person's life as well as that of their carers. The social functioning of aphasia was also presented including the desire to return to work by young people with aphasia (see section 2.3.3 and 2.3.4) and the various barriers that are reported to prevent this, including language difficulties particularly when employed in service delivery positions. Apart from employment the impact of aphasia on various social relationships has also been explored (see section 2.3.2). Finally, the sudden and sometimes catastrophic changes that occur within the family unit as a direct result of a family member becoming aphasic has also been addressed (see section 2.3.3). Although participants with aphasia in the study by Ross and Wertz (2003) reported having priorities other than communication difficulties (see section 2.3), it has been demonstrated that communication impairment directly impacts upon those identified areas. For instance an individual's independence and autonomy is negatively affected where a person is dependent upon their family and friends to explain to them what they do not understand and to translate what they are trying to say to others (see section 2.3.3 and 2.3.4). Communication impairment has also been demonstrated to directly impact upon the development and maintenance of social relationships, which includes the continuing support of non-aphasic friends. Aphasia also impacts upon a person's ability to access information as this by its very nature is communicated via the written or spoken word. It also erodes a person's confidence in situations where they need to use their limited communication abilities (e.g. using public transport or accessing the health services). While the literature is in agreement with the priorities of people with aphasia being elements other than communication (as highlighted by Ross and Wertz, 2003), this discussion has demonstrated that it is language difficulties that affect the ability to access these quality of life issues.

Consideration of all the issues that impact upon the life of a person with aphasia - difficulty reintegrating into the workforce, the community and their own family unit, it is clear that a major effect of aphasia involves social isolation (Code and

Herrmann, 2003; Keppel and Crowe, 2000; Sarno, 1997) and negative changes in self-esteem (Ellis-Hill and Horn, 2000; Keppel and Crowe, 2000; Christensen, 1997). A survey conducted by the National Aphasia Society in the United States compiled the experience of over 200 stroke survivors who had residual aphasia one year following stroke onset. The results found that 90% of the group stated that social isolation was their primary problem and over 75% of participants stated that they felt that non-aphasic people often avoided contact with them because of their communication difficulties. Specifically mentioned were loneliness, difficulty making friends, lowered self-esteem and depression.

Aphasia has been demonstrated to have a vast impact upon a person's emotional well-being, social functioning, family relationships and their ability to actively engage in everyday pleasurable as well as functional activities. Speech and language therapists are involved in the rehabilitation of these individuals both at the acute and chronic stages of their stroke. The outcome aim of rehabilitation is to return each person to his or her highest potential level of recovery. According to the World Health Organisation's framework, ultimate rehabilitation outcomes should relate to measurement of life participation, such as returning to employment, community integration and life satisfaction (ICF, 2001). These vocational and social outcomes of rehabilitation are thought to be critical determinants of the usefulness of rehabilitation (Hinckley, 2002). Outcomes such as returning to employment may involve a change of responsibilities and retraining in a new area of a given company/ workplace. Bryan et al. (2003) reported that of the 211 people with aphasia who returned to work 16.5% obtained a different job. These vocational changes may involve learning new skills and will most probably involve the integration of new vocabulary pertaining to these newly learned skills. From these participants with aphasia 33% accessed further education, directly involving the learning or acquisition of new terminology and skills. The potential of an individual to learn new information following brain damage has not been thoroughly researched with the literature regarding the learning of new vocabulary in particular being sparse. Before the question regarding the capability or potential of the damaged brain to learn new vocabulary is addressed, the overall potential of the brain to re-access already held vocabulary during the rehabilitation of aphasia will be explored.

2.4 REHABILITATION OF APHASIA

The problems associated with aphasia and the consequential impact that aphasia has on people's lives have been discussed above. The language functioning of some people with aphasia does resolve spontaneously following a stroke as part of the recovery process (see section 2.2.1), while other people require rehabilitation from speech and language therapists. The impact and the consequential implications of having aphasia for the individuals themselves, their families and society as a whole (see section 2.3) highlight the importance of the rehabilitation of language difficulties caused by aphasia. The speech and language therapist works closely in partnership with the person with aphasia and their families/ carers endeavouring to bring them to their highest communicative potential. So what does this rehabilitation involve and is there evidence for its efficacy?

2.4.1 The efficacy of aphasia rehabilitation

As early as seventy years ago Weisenburg and McBride (1935), (as quoted in Butfield and Zangwill, 1946), indicated that evidence from their research suggested that language therapy or 're-education' increased the rate of improvement over and above that which occurred from spontaneous recovery alone. Butfield and Zangwill (1946) instigated one of the first studies which highlighted the question of the efficacy of language rehabilitation, stating that at that time there were no means of measuring whether the effects of language recovery were as a result of spontaneous recovery or what they termed 're-education' of language itself. The efficacy of language rehabilitation was also addressed by Darley (1972) who posed similar questions regarding the possible measurable gains from language therapy compared to spontaneous recovery alone. Since then researchers have addressed this question. There is currently extensive literature in the field of language rehabilitation. Enderby and Emerson (1995) report that there are more studies into the efficacy of language therapy for aphasia published over the past twenty years than for any other client group.

One such review of the efficacy of language therapy for aphasia was the Cochrane review which concluded that aphasia rehabilitation following stroke was inconclusive within a randomised control trial (Greener, Enderby and Whurr, 2005). However, due to the heterogeneous nature of aphasia and ethical considerations, which make it difficult to select random 'no-treatment' groups, much current research in aphasia rehabilitation reports outcomes of single case studies or case series usually with chronically aphasic people who act as their own controls (Basso and Caporali, 2001). Additionally, the meta-analyses of such studies enable the calculation of the efficacy of language therapy on the basis of all available evidence (Basso, 2002). Basso (2002) asserts that these meta-analyses demonstrated that participants who received language therapy improved over those individuals who did not. Robey (1998) also reviewed 55 such studies and found a significant effect of language therapy on recovery where the amount of therapy provided was positively related to the magnitude of change of communicative improvement. Robey (1994) asserts that there is a clear superiority in the performance of a person receiving treatment by a speech and language therapist. From their extensive review, Enderby and Emerson (1995) confirm that the rehabilitation of language is successful and advise that therapists must adopt the best therapy methods and eliminate ineffective or even harmful aspects of language rehabilitation. It is therefore widely accepted that language therapy for people with aphasia can be effective (Basso, 2002).

Rehabilitation is not thought to alter the pattern of the natural course of restitution, but rather facilitates recovery in some patients who would otherwise not demonstrate any improvement and accelerates it in others (Basso, 1992).

While the rehabilitation of aphasia is considered efficacious as a whole it is effective to various degrees for each person with aphasia. As previously stated, the aphasic population is a heterogeneous group presenting with different facets and severity of language impairment. The extent of the effectiveness of language rehabilitation is also variable for this population, where at one end of the spectrum people with aphasia regain almost all pre-morbid language abilities, others regain partial functioning and yet others regain little if any spoken and/ or written communication following rehabilitation. In situations where language therapy does not restore full communicative ability alternative means of communication may be employed to enable the person to compensate for their language impairment, such as low-tech communication boards or high-tech communication systems. However the focus of this investigation is not on the compensation of impaired language function but rather on the restoration of language function during the rehabilitation process. During the period of spontaneous recovery and chronic phases of recovery following a stroke the rehabilitation process is limited by the physical potential of the damaged brain to recover and heal. Therefore before discussing the theoretical possibilities of rehabilitation it is important to consider a number of factors that directly affect the rehabilitative process as well as its limitations. The biological processes of the brain will now be addressed considering the potential of plasticity in the adult brain, its potential for recovery following damage and the limitations to this recovery.

2.5 THE PLASTICITY OF THE ADULT BRAIN

It was previously thought that the reorganisation (plasticity) of the brain was only possible in childhood and was considered to be a fundamental property of children's brain development, during which time their neural systems stabilise and optimal patterns of functioning emerge (Stiles, 2000). Various upper age limits were imposed upon this plasticity, for example, aged 12 years (Lenneberg, 1967) and even aged five years (Krashen, 1973). These claims were based on observations of children being more resilient than adults following brain injury and therefore, the developing brain was considered more conducive to plastic reorganisation following injury than the more mature adult brain (Stiles, 2000). However recent studies both in animal and human research have provided evidence that the adult brain's neural system is also capable of reorganising both through continual development during the acquisition of knowledge and skills and also following brain damage. Before evidence demonstrating the plasticity of the adult brain is presented, the anatomical and physiological processes will be described, together with the potential of these processes to recover from damage and any limitations to this recovery process. Any theory of rehabilitation would be limited to the capabilities and limitations of the brain network (being the physical manifestation of any model or theoretical account) and this will now be discussed.

2.5.1 The physical processes of the brain

The surface of the brain (cortex) does not have precise visible anatomical divisions, however researchers have developed a map of the brain depicting functional areas of the cortex (Mesulam, 1998) which identifies sets of neurones relating to each body part. These neurones are grouped together and responsible for the operating and functioning of that particular body part. Throughout the human lifespan the brain is continually developing what Robertson (1999) terms as a 'trembling web of 100 billion brain cells' (neurones) and approximately 100,000 billion connections are made in response to everything that we learn and experience in life. According to Hebbian principles of learning each neurone receives a surge of electrical and chemical impulses directing it to either connect or disconnect with other neurones. To make these connections the group of neurones fire simultaneously and after a few repetitions of firing together the synapses between the cells chemically change so that on future occasions when one of these neurones fire the other neurones fire in tandem. Therefore cells that fire together wire together (Hebb, 1949). These connections, reportedly numbering more than the stars in the galaxy, are continually being made and broken again as we learn and forget our daily experiences and while individual connections change, the template of these experiences and formed memories is preserved (Robertson, 1999). Therefore, although we may consciously forget what we have learned the template or pattern of what we learn remains ready for us to reconnect to it again. According to Hebbian principles of learning, when damage occurs in the human brain these broken or damaged connections in the cortex can reconnect themselves through activation of the surviving undamaged neurones. This pattern can survive even if the cells themselves die through brain damage. When this happens the other partly connected neurones can become reconnected (Robertson 1999). However if this repair and reconnection is to occur a minimal 'critical mass' of cells must survive the damage. If more than this critical mass of neurones in a particular circuit is destroyed then the patterns or template of the experience or skills themselves may be permanently lost. As cells that 'fire together, wire together' it is important when rehabilitating the damaged brain that the stimulation facilitates the recovery of function without making faulty connections (Robertson, 1999; Robertson and Murre, 1999).

2.5.2 Evidence of plasticity in adults

Previously, evidence of the ability of the adult brain to reorganise was taken from animal studies. However recently the same phenomenon has been demonstrated with human adults using advanced brain-scanning techniques, so refuting previous allegations that only the developing brain could reorganise. Evidence from both brain-scanning techniques as well as post-mortems has demonstrated that many skills acquired in adulthood are intricately imprinted upon the brain. Musicians who played stringed instruments resulting in an increased use of their fingers have been shown to have a permanent enlargement of the cortical representation in the relevant areas of their brain, with the size of this enlargement being proportional to the number of years they had devoted to learning and practising this skill (Elbert, Pantev, Weinbruch, Rockstroh and Taub, 1995). Enlargements of cortical areas have also been found in typists, machine operators and appliance repair-men relating to their particular skill, for example more densely-branched neurones in the finger areas than those responsible for other body parts (Scheibel, Conrad, Perdue, Tomiyasu and Wechsler, 1990). Karni, Meyer, Jezzard, Adams, Turner and Ungerleider (1995) also demonstrated that the prolonged performance of complex motor tasks is associated with motor cortical plasticity. Experienced Braille readers have also been observed to present with a larger cortical representation of their reading finger in comparison with their own non-reading fingers as well as the fingers of control individuals (Pascual-Leone and Torres, 1993). The authors suggest that this was as a result of focussed sensory input and a direct result of the acquisition or learning of the Braille reading skill.

In fact, it has been demonstrated that even the mental rehearsal of a skill can foster connections between neurones (Stephan, Fink, Passingham, Silbersweig, Ceballos-Baumann, Frith and Frackowiak, 1995; Pascual-Leone, Dang, Cohen, Brasilneto, Cammarota and Hallet, 1995). Mental rehearsal is often employed by athletes when they sustain injury and are unable to physically train. These athletes visualise themselves performing their sport with resultant neuronal activity changes in response to this mental rehearsal (Robertson, 1999). Johnson-Frey (2004) has also carried out preliminary work assessing the usefulness of mental rehearsal using motor imagery to facilitate functional reorganisation in hemiplegic stroke patients. Preliminary results are reported to be promising. Interestingly, significant subcortical changes have also been demonstrated in patients who present with hysterical conversion i.e. they experience a loss or impairment of function that cannot be explained by any known organic neurological disease, indicating plasticity of brain regions (Vuilleumier, Chicherio, Assal, Schwartz, Slosman and Landis, 2001; Marshall, Halligan, Fink, Wade and Frackowiak, 1997) which then resolved after the conversion symptoms had diminished (Vuilleumier et al., 2001).

Cortical plasticity has also been demonstrated with adults who are born with physical difficulties such as syndactyly (webbed-finger syndrome), where the fingers of individuals are webbed together from birth with the fingers being unable to move independently from each other (Robertson, 1999). The sensory map on their brains reflected this physical anomaly where clusters of neurones for each individual finger were merged into just one area and the brain considered the fingers as one entity. Brain-imaging techniques demonstrated cortical reorganisation following surgery which separated the fingers allowing them to move independently from each other and it was observed that each finger developed its own separate neurone base. Robertson (1999) advises that this is a result of Hebbian learning where neurones, which begin to fire simultaneously, consequently wire together as the individual fingers begin to move independently from each other and neurones for each individual finger became connected to its own neuronal base. This process and its reverse have also been observed in animal studies.

The evidence presented above demonstrates that physical and motor learning occurs in the adult brain demonstrated by increased and complex neuronal connections (Robertson, 1999). Abundant evidence therefore demonstrates that the intact healthy adult brain is amenable to physical change (plasticity) despite earlier assertions that this is only possible in the developing brain. In the next section the questions arise as to the adaptability and potential of the brain when the neurones themselves are damaged. Additionally, the requirement of experience-dependent recovery through rehabilitation will also be addressed.

2.5.3 Evidence of plasticity in the recovery of motor and sensory function

There has been much evidence (from adults with acquired brain damage following stroke) for cortical plasticity in the motor and sensory neuronal areas. Research into the recovery of hemiplegic limbs have shown that highly repetitive and specifically targeted hand and finger movements in a person's hemiplegic arm produces significantly greater improvement in function than non-specific exercises which solely focussed on spasticity reduction. People participating in this general treatment approach alone did not experience a significant improvement in the motor capacity of their hand indicating the requirement for guided experience-dependent rehabilitation (Bütefisch, Hummelsheim, Denzler and Maruitz, 1995). Another investigation incorporated 'constraint-induced' therapy involving participants with post-stroke upper limb hemiplegia. It was demonstrated that improvement in function was possible by encouraging the person to use the hemiplegic limb while at the same time discouraging them from using their undamaged limb (Taub and Wolf, 1997; Taub, Miller, Novak, Cook, Fleming, Nepomuceno, Connell and Crago, 1993). Two weeks of this training resulted in significant improvement in the arm's motor function maintained at two year follow-up. Following this 'constraint-induced' therapy, plasticity in the motor cortex was identified and a shift in laterality towards the undamaged hemisphere was observed for four chronic stroke patients with hemiparesis (Schaechter, Kraft, Hilliard, Dijkhuizen, Benner, Finklestein, Rosen and Cramer, 2002).

Evidence is also available for functional recovery in preliminary studies related to successful gait rehabilitation (Hesse, Bertelt, Jahnke, Schaffrin, Baake, Malezie and Mauritz, 1995), rehabilitation of hemianopia following stroke

(Kasten and Sabel, 1995) and replicated studies with participants presenting with visuo-spatial neglect (Mattingley, Robertson and Driver, 1998; Ladavas, Berti, Ruozzi and Barboni, 1997; Robertson and North, 1992; 1993; 1994; Robertson, North and Geggie, 1992). This evidence suggests that the damaged brain is amenable to reorganisation and restoring functional use to impaired limbs, gait, hemianopia and visuo-spatial neglect following a stroke. However, it is important to ascertain if this plasticity occurs as a direct result of rehabilitation or if the brain could recover functions adequately without experience-dependent rehabilitation.

2.5.4 Does plasticity require therapeutic direction?

As discussed, there is abundant evidence that the adult brain physically adapts as it acquires and learns new information by making and reforming patterns of neuronal connections. However before a theory of rehabilitation is developed it needs to be demonstrated that the recovery of function following brain damage requires the guidance of experience-dependent rehabilitation, without which it risks maladapted neurones further causing functional impairment. Some of the evidence presented above asserts that the provision of specifically targeted experience was found to produce significantly greater improvement in hand and finger function than with more generalised exercises alone (Bütefisch et. al, 1995), which is what rehabilitation ultimately aims to provide. There are a number of studies which suggest the requirement for therapeutic direction to eliminate or reduce maladaptive neuronal connections.

Evidence of maladaptive connections occurring as a result of acquired deafness is considered to cause synaptic compensation for decreased sensory input resulting in false auditory sensations i.e. tinnitus (Jastreboff, 1990). Further evidence can be found with healthy adults who had a history of normal development but experienced the development of maladaptive connections as a result of constant repetition of a particular skill, i.e. focal hand dystonia or occupational hand cramp. Classen (2003) advises that there is strong evidence that abnormal neuroplasticity mechanisms are present in focal hand dystonia. As previously discussed in the acquisition of skills (see section 2.5.2), string musicians presented with enlarged cortical areas due to the use-dependent alteration of cortical areas of the particular fingers used to strum the strings. Focal hand dystonia of such musicians were investigated, where this same use-dependent plasticity also occurred causing maladaptive overlapping of the somatosensory cortical organisation (Candia, Schafer, Taub, Rau, Altenmüller, Rockstroh and Elbert, 2002; Elbert, Candia, Altenmüller, Raysterr, Rockstroh, Pantev and Taub, 1998; Candia, Elbert, Altenmüller, Rau, Schafer, Taub, 1999). Candia et al. (2002) employed constraint-induced therapy to reverse this dystonia (sensory motor retuning) which resulted in improved performance. Writer's cramp (another form of hand dystonia) develops in the absence of known structural changes in the nervous system (Classen, 2003) and is considered to be the result of overuse of a fine motor skill, which is characterised by excessive muscular activation during the repetitive task of writing (Marsden and Sheehy, 1990). Rapid functional reorganisation was induced using associative stimulation with participants with writers' cramp (Quartarone, Bagnato, Rizzo, Siebner, Dattola, Scalfari, Morgante, Battaglia, Romano and Girlanda (2003). Quartarone et al. (2003) assert that while the exact mechanisms that mediate the abnormal connections in sensorimotor plasticity are unknown, it can be hypothesized that repetitive peripheral sensory stimulation during skilled manual tasks might lead to maladaptive plasticity.

Additional evidence comes from adults who have a history of normal development but have had a limb amputated. More than 80% of people who have undergone amputation experience what is commonly referred to as the phantom limb phenomenon (Hunter, Katz and Davis, 2003). This phenomenon involves the amputee reporting that they sense the presence or awareness of the severed limb, often experienced as paralysis (Ramachandran and Hirstein, 1998), tingling, itching or painful sensations (Hunter et al. 2003) even as long as 25 years after the loss of the limb (Sherman, Sherman and Parker, 1984). This phenomenon indicates that the brain has not fully registered that the limb is no longer part of the body and continues to feel sensations in that (nonexistent) arm or leg. Maladaptive cortical reorganisation has also been found to occur in amputees where the sensory regions from their face and upper arm re-map to occupy the cortical territory previously held by the now amputated limb (Yang, Gallen, Ramachandran, Cobb, Schwartz and Bloom, 1994). Functional deviancies reported by amputees have supported these findings, for example when their faces were touched with vibration or various temperatures of water they felt the sensation as if it were on their phantom limb, further indicating maladaptive connections made by unguided plasticity. Research has demonstrated that it is possible to reverse these maladaptive connections using experience-dependent rehabilitation (Ramachandran and Hirstein, 1998). This phantom limb phenomenon provides fundamental insights into the functional reorganisation of the human brain (Ramachandran and Hirstein, 1998). That is, these studies demonstrate that the neuronal connections in the brain can be re-routed or re-mapped through experience-dependent learning as neural circuits are trained or even tricked into changing their connection patterns (Robertson, 1999). Additionally, these studies also demonstrate that without such guided plasticity maladaptive connections may be made reducing the functional ability of the individual.

In summary, the evidence presented above has demonstrated the ability of the adult brain to recover function following a stroke and brain-imaging techniques have identified cortical plasticity in the motor and sensory cortex as a result of experience-dependent rehabilitation. The importance of rehabilitation has also been demonstrated in guiding this cortical reorganisation with evidence indicating that maladaptive neural connections can be made if the brain is left to recover independent of any structured guidance. This investigation aims to ascertain if the adult brain can learn new vocabulary following cortical damage therefore evidence of plasticity in the recovery of language function will now be presented.

2.5.5 Evidence of plasticity in the recovery of language functions

The adaptability of the brain to recover motor function following neuronal damage has been presented above (see section 2.5.3). As this investigation is concerned with the restitution of language function, the evidence regarding the plasticity of the language areas of the brain will be presented and discussed, beginning with the ability of the child's brain to learn language despite the presence of language impairment. Specific language impairment is a developmental disorder where children may have difficulty in the recognition, learning and expression of language, in the presence of normal development in all other areas. The rehabilitation of phoneme discrimination with these children in a number of studies found that the repeated auditory stimuli exercises improved both the recognition and discrimination of the target trained sounds (Merzenich, Jenkins, Johnston, Schreiner, Miller and Tallal, 1996; Tallal, Miller, Bedi, Byma, Wang, Nagarajan, Schreiner, Jenkins and Merzenich, 1996). The authors assert that this training procedure may have caused the plastic reorganisation of the relevant neurones responsible for temporal segmentation in these children's brains. Therefore plastic reorganisation of language function is evidenced in children but as previously discussed children's brains are considered to be more pliable than the adult brain (see section 2.5).

It has been demonstrated that the adult brain can reorganise following neural damage to the motor and sensory cortex (see section 2.5.3) however, language is a highly specialised mental function and one that is not readily taken over by adjoining parts of the brain following damage (Cappa, 2000; Robertson, 1999). There is however empirical evidence that demonstrates that the adult language system is receptive to rehabilitation training. An investigation using Positron

Emission Tomography (PET) scans analysed six people who had survived strokes affecting large areas on the Wernicke's region of the brain (crucial for understanding language) and who had received intensive language therapy (Weiller, Isensee, Rijntjes, Huber, Muller, Bier, Dutschka, Woods, North and Diener, 1995). Following this therapy they recovered their understanding and expression of language. The PET scans revealed the outcome of this recovery. Cortical regions outside Wernicke's area were illuminated (in both the left and right hemisphere) when these individuals performed tasks using functions that had originally involved the now severely damaged Wernicke's area. This indicated that cortical reorganisation occurred enabling the restoration of language function. A further study of three left hemisphere stroke participants (2-14 years post-stroke) investigated cortical plasticity following treatment for word-finding difficulties (anomia) using magnetoencephalography (Cornelissen, Laine, Tarkiainen, Jarvensivu, Martin and Salmelin, 2003). The treatment elicited statistically significant training induced changes in cortical activity adjacent to each participant's site of lesion. Additionally, there was no evidence of increased right hemispheric involvement following training, supporting the view that restoration of language-related networks in the damaged left hemisphere is crucial for recovery from anomia (Cornelissen et al. 2003).

The success of constraint-induced therapy (CIT) in the restoration of limb function for people in the chronic stages of stroke has been discussed and incorporates the restraining of the unaffected limb forcing intensive use of the damaged limb (see section 2.5.3). Pulvermüller, Neininger, Elbert, Mohr, Rockstroh, Koebbel and Taub (2001) modified this CIT for language rehabilitation and evaluated it with people who had previously participated in conventional language therapy and who had reached a maximum in recovery of language function. Pulvermüller et al. (2001) observed that constraint-induced aphasia therapy, which constrained the use of compensatory communication strategies such as drawing and gesture, led to a significant improvement in the language abilities of ten participants with chronic aphasia (average 8.5 years post-onset), whereas this was not observed in the seven participants in the control group. Meinzer, Elbert, Wienbruch, Djundja, Barthel and Rockstroh (2004) also investigated intensive language training with 28 people with chronic aphasia and employed the restraining of non-verbal communication. Findings noted significant improvement of language function in 16 participants with the other 12 participants demonstrating some improvement. Fundamentally, brain plasticity was observed where the magnitude of change of brain activity correlated with the amount of change in language function. Meinzer, Djundja, Barthel, Elbert and Rockstroh (2005) replicated Pulvermüller et al.'s (2001) study with a larger sample. They also evaluated an additional group (CIATplus) which included written materials and photographs of everyday situations and incorporated a training module including a participant's relative in daily one-to-one communication exercises. The findings supported that of Pulvermüller et al.'s (2001) study and reported that recovery was equally found among participants irrespective of age, severity of aphasia and time post-onset. Results were stable at a six-month follow-up. Patients and relatives both reported an increased level of comprehension and amount of communication used in everyday communication. Functional improvement was more significant in participants in CIATplus group who received additional training in daily communication. Meinzer et al. (2005) consider that it is the intensity in therapy that appears to be crucial for the successful rehabilitation of chronic aphasia as no further improvement of language function was noted during follow-up assessment despite receiving non-intensive language therapy. They assert that in the chronic stages of aphasia any validated language intervention may benefit from an intensive treatment programme.

This evidence indicates that plasticity induced restoration of adult language function does occur (Meinzer et al., 2004; Pulvermüller et al. 2001 and Weiller et al. 1995) and that without experience-dependent guidance i.e. therapeutic rehabilitation, function can be limited (Pulvermüller et al. 2001) (suggesting that perhaps maladaptive neuronal connections are created). However it does not address the process of rehabilitation and why some people with aphasia who receive therapeutic intervention recover more language functioning than others. It is important therefore to investigate the limitations on the rehabilitation of language (which requires accurate neuronal connections), as it would be envisaged that these limitations would have similar impact upon the learning of new vocabulary (which also requires accurate neuronal connections).

2.6 FACTORS INFLUENCING LANGUAGE RECOVERY

As previously discussed (see section 2.4.1), while aphasia therapy is considered efficacious, the extent to which language recovers is variable within the aphasic population. The evidence presented indicates that recovery of language function involves the reorganisation of neuronal connections. It can therefore be speculated that any factors limiting the recovery of language function could directly affect the potential for cortical plasticity, which in turn may affect the ability of the individual to make new neuronal connections in the form of new vocabulary learning. The literature provides evidence identifying limitations such as pre-morbid factors, biological limitations and severity of loss of functions following stroke. These issues will now be discussed below.

2.6.1 Pre-morbid factors

2.6.1.1 Age at onset

Buell and Coleman (1981) state that human ageing brings with it many clinical signs indicating that the brain is subject to age-associated degenerative processes. Jacobs and Scheibel (1993) found that brains (post-mortem) under aged 50 years had significantly greater total dendritic length values in the left hemisphere than older brains. However this was not the case for all brains as the oldest person in the study had dendritic measures well above average. This supports some smaller studies that suggest that the number of dendrites actually increases with age (Buell and Coleman, 1981). Their study found significantly larger dendritic trees in adults, aged 68-92 than in younger adults (aged 44-55). Johansson (2000) asserts that the dendritic loss of ageing is compensated to some extent by dendritic growth where a post-mortem examination demonstrated that neurological healthy 80 year olds had longer dendritic trees than those of 51 year olds.

Bagg, Pombo and Hopman (2002) advise that age has been identified as a prognostic factor in recovery following stroke in a number of studies reporting associations between age and poor outcome. The data however is equivocal, with some studies showing that younger patients had a more favourable outcome than older ones (Kalra, 1994; Holland, Greenhouse, Fromm and Swindell, 1989; Shewan and Kertesz, 1984; Marshall and Phillips, 1983; Marshall, Tompkins and Phillips, 1982) whereas other studies suggested that age is not a prognostic factor (Bagg et al., 2002; Pedersen, Jørgensen, Nakayama, Raaschou and Olsen, 1995). Robertson and Murre (1999) state that although neuronal plasticity is evidenced in the adult population the potential for recovery is greater for younger adults. Bagg et al. (2002) aimed to discriminate between the influences of age itself and various factors that are associated with ageing on functional outcome. They found that age alone showed a small but significant effect on functional outcome. However they stress the small size of the effect stating that the association between poor outcome and age could be explained by additional disabilities or co-morbidities that the people presented with. They advise that age itself could be associated with lower functional outcome because of a limited physical tolerance to intense rehabilitation, slower functional recovery or both.

Studies have not always found age to be a prognostic factor (Basso, 1992; Poeck, Huber and Willmes, 1989). Basso (1992) also states that if there were clear age differences in recovery it would only indicate that changes occur with age, without suggesting the possible causes of these changes. However Alexander (1994) advises that on the whole older people present with a worse functional outcome than younger people. Pedersen et al. (1995) found the influence of age on recovery was significant but minimal. Pedersen, Vinter and Olsen (2004) found an age difference between Broca's and Wernicke's aphasia one year after stroke but not in the initial acute stages. They suggested that the 'true' aphasia is initially masked by diaschisis and felt that age was not a predictor of recovery. De Riesthal and Wertz (2004) advise that many studies vary in terms of communication measures used (impairment-based or functional) and method of measuring amount of change or improvement. Nakayama, Jørgensen, Raaschou and Olsen (1994) advise that age does not independently influence stroke outcome neurologically but rather in aspects of activities of daily living, suggesting a poorer compensatory ability in elderly stroke patients.

2.6.1.2 Years of education

As discussed, the acquisition of skills and information contributes to the complexity of neuronal connections in the brain (see section 2.5.2) therefore the more education that a person experiences, the greater the complexity and number of neuronal patterns are present in the language areas of the brain (Jacobs, Schall and Scheibel, 1993). Education refers not only to the formal education system but also to the long-term intellectual experiences resulting from that education (Jacobs et al., 1993). Jacobs et al. (1993) found that the more education that an individual experienced the more complex and interconnected neural connections they possessed compared to less educated individuals. While it was not possible to prove whether the more complex number of neurones existed as a result of attending university, or whether participants were more predisposed to attending higher education because of an inherently more complex neuronal system, environmental studies reveal the importance of a stimulating environment for shaping cortical development. Robertson (1999) suggests that education nurtures a better-connected network of neurones and as a result the patterns of skills and memories are less easily destroyed. He stated that one of the great benefits of education is that you actually learn how to learn and this involves skills of thinking, remembering, planning and problem solving. Due to this education process a more densely connected network of neurones evolves from the increased number of brain cells that have become wired together through firing together. It is therefore more likely that skills and memories woven into these wired connections can be recovered following damage. De Riesthal and Wertz (2004) assert that years of education as a prognostic factor in recovery from aphasia is debatable. Smith (1971) reports that a person with more years' education tends to make more improvement following aphasia therapy. Tompkins (1990) however observed that variables such as education are poor predictors of improvement in aphasia. De Riesthal and Wertz (2004) also noted that the number of year's education was not significantly correlated with recovery.

2.6.1.3 Cognitive Reserve

The variability in both the severity and duration of aphasia, and the successful recovery of language following cortical damage has been discussed (see section 2.4.1). Variation is also observed in the severity of cognitive functioning despite individuals presenting with similar neurological damage. This phenomenon is often explained with the hypothetical concept of 'cognitive reserve' (Staff, Murray, Deary and Whalley, 2004; Whalley, Deary, Appleton and Starr, 2004; Kesler, Adams, Blasey and Bigler, 2003). This hypothesis suggests passive and active factors which are thought to influence the capacity of the brain to withstand cognitive decline/ damage to a predetermined threshold after which cognitive deficits appear (Staff et al., 2004). The size of a person's brain is one such passive factor hypothesised to influence cerebral reserve, suggesting that larger intracranial capacity could withstand more brain ageing (or injury) before cognitive impairment becomes detectible than smaller intracranial capacity (Kesler et al., 2003). Active processes considered to be factors involved in accumulating cerebral reserve include the intellectual challenges experienced throughout our lifetime, such as intelligence, education and occupational levels (Staff et al., 2004; Whalley et al., 2004; Kesler et al., 2003; Plassman, Welsh, Helms, Brandt, Page, Breitner, 1995).

Some studies have attempted to evaluate the impact of ageing on cognitive decline. One such study in Scotland replicated the Scottish Mental Survey of 1932 (school children aged 11) with 235 of the same participants (aged 77 at follow-up) comparing the findings to the data of 1932 and also provided MRI data for 98 of these participants (Staff et al., 2004). Unlike Kesler et al. (2003) cerebral size was not supported as a passive factor in cognitive reserve. It was reported that childhood intelligence contributed to non-verbal reasoning abilities at age 77 years and both education and a cognitively complex occupation predicted higher cognitive ability in old age. Additionally, relationships were found between memory and education, memory and occupation, as well as reasoning and occupation. An interesting trend in this replicated study indicated a substantial stability in the rank-ordering of human intelligence across the life span where children who scored highly in assessments at age 11 tended to score highly at age 77 and vice versa. A cross-sequential study in Seattle also recorded the intellectual and cognitive capacity of a population from childhood to adulthood (over 5000 participants) (Schaie, 1994). This study reported a decline of intellect with ageing in areas of inductive reasoning, spatial orientation, perceptual speed and verbal memory, however, there was much less age related decline in verbal and numerical ability.

It is however difficult to establish baseline measures of active factors such as pre-morbid intelligence and cognitive status, to enable comparison with a person's current cognitive status (Staff et al., 2004; Starr, Nicolson, Anderson, Dennis and Deary, 2000). One difficulty in assessing and estimating pre-morbid intelligence is that the measurement of intelligence is only as good as the assessment used, not all intellectual capabilities can currently be measured, for example, creativity or wisdom and there is not a general consensus as to what intelligence actually is (Deary, 2001). Starr et al. (2000) note the difficulty in the accurate measurement of cognitive impairment and intelligence following a stroke as many assessments are inappropriate for use with people post-stroke and also that pre-morbid cognitive function usually needs to be estimated after the stroke has occurred. The impact of stroke could impair test performance particularly when related to linguistic and visuospatial deficits therefore someone with aphasia may not be able to demonstrate their intellectual capabilities where verbal responses are required.

2.6.2 Biological limitations

As already discussed (see section 2.5) recovery following stroke and the potential for recovery is limited by the capabilities and limitations of the physical brain. However, this is not a straightforward relationship. Research on the different aetiologies of stroke, i.e. infarct versus haemorrhage, and their effect on recovery is rare and has produced conflicting results (Basso, 1992). Other studies have attempted to evaluate the location and extent of the lesion on recovery. However, it is difficult to assess this factor independently from the initial severity of aphasia which in turn is directly associated with location and extent of lesion (Basso, 1992).

2.6.2.1 Lesion size and site

As discussed (see section 2.5.1) a minimal 'critical mass' of neurone cells are required to survive if neuronal repair and reconnection is to occur (Robertson, 1999; Robertson and Murre, 1999). This suggests that the greater the damage, the less chance of this minimal number of neurones surviving with the possible permanent loss of particular skills. Naeser and Hayward (1978) report that small lesions appeared to correlate with mild aphasia types. Kertesz, Harlock and Coates (1979) reported that larger lesions produce more lasting language impairment finding a positive correlation between lesion size and recovery of comprehension. They advise that the size of lesion is more significant in determining the degree of aphasia than its location with anomic aphasia, however in contrast to this a small lesion positioned in Wernicke's area may produce severe aphasia. Basso (1992) states that the effect of the magnitude of a lesion on the initial severity of aphasia is unquestionable but that once the initial severity has been accounted for the effect of lesion size on recovery of language is ambiguous. Ludlow, Rosenberg, Fair, Buck, Schesselman and Salazar (1986) reported a 15-year follow-up study and reported that the size of the lesion was not a predictor in itself however, where both the anterior and posterior language areas were damaged language showed less recovery. According to Basso (1992), Naeser, Helm-Estabrooks, Haas, Auerbach and Sprinivasan's (1987) is the only study that directly studies the effect of the location of lesion and its relation to recovery. Their results indicated that a large or posterior lesion initially causes severe aphasia but, as with lesion size, the effect on the amount of recovery is not clearly demonstrated. Basso (1992) states that the location of the lesion has more influence on the initial severity of aphasia than on the degree of recovery.

In summary, the relationship between the magnitude and location of brain lesions is complex and appears to be interlinked with the initial severity of aphasia. Additionally, the relevance of size and site of lesions may have different relevance for function; for example, a small lesion in the language area of the brain is more disruptive for language than is a large lesion in the frontal lobes (Basso, 1992).

2.6.3 Initial functional severity

2.6.3.1 Initial severity of aphasia

Robey (1998) performed a meta-analysis of various aphasia rehabilitation studies and found that (with a limited amount of evidence) recovery following intervention with people with moderate and severe aphasia was not encouraging. However he states that many single case studies have shown positive therapeutic outcomes with large gains being achieved by people with severe aphasia when treated by speech and language therapists. There is general agreement that the initial severity of aphasia is significantly related to outcome (De Riesthal and Wertz, 2004; Pedersen et al., 2004; Basso, 1992; Shewan and Kertesz, 1984). In fact, Pedersen et al. (1995) state that this initial severity is the single most influencing factor for ultimate language function. This has been confirmed whenever the level of initial severity was included in studies evaluating recovery and whichever language performance was studied (Basso, 1992). Therefore, people with aphasia whose language problems are initially less severe appear to regain a higher level of function than those with more severe impairment.

2.6.3.2 Emotional status

As previously discussed (see section 2.3.1) one of the impacts of post-stroke aphasia is emotional disturbances, such as apathy (Starkstein, Fedoroff, Price, Leiguarda and Robinson, 1993), anxiety and depression, both in the acute and chronic stages of recovery (Robinson, 2003; Spalletta et. al. 2002; Keppel and Crowe, 2000; Beblo et al., 1999; Kauhanen et al., 1999; Shimoda and Robinson, 1998; Astrom et al. 1993; Sarno, 1993 and Bolla-Wilson, Robinson, Starksein, Boston and Price, 1989). Robinson (2003) reports a lack of standardised methods and criteria for diagnosing post-stroke depression but according to DSM-IV depressive-like episodes are acceptable for diagnosis. He reports that using this criterion 19.3% of people who experience stroke present with major depression and 18.5% with minor depression. While it is difficult to assess depression in people with severe aphasia, it has been demonstrated that people who present with post-stroke aphasia are not associated with higher rates of depression compared with people who have had a stroke but are not aphasic (Spalletta et al. 2002). Depression and functional outcome have been shown to be correlated (Herrmann, Black, Lawrence, Szekely and Szalai (1998). In fact Robinson (2003) states that post-stroke depression in hospital is one of the strongest factors impairing recovery in activities of daily living over a two year period and effective treatment of depression has been shown to improve functional recovery. Emotional difficulties such as depression and anxiety not only impact upon a person's quality of life but also on their motivation, language and cognitive performance (Beblo et al., 1999), which in turn affects their participation and recovery in rehabilitation.

2.6.3.3 Cognitive impairment

There is increasing evidence that communication problems experienced by people with aphasia are not attributed to their language impairment alone but are confounded by additional cognitive impairments (Helm-Estabrooks, 2002; Keil and Kaszniak, 2002; Purdy, 2002). There are considered to be five primary domains of cognition: attention, memory, executive function, language and visuospatial skills (Helm-Estabrooks, 2002). These cognitive processes are involved in the acquisition and manipulation of the knowledge that we possess (Bayles, 2001) and are recruited and employed to some degree during the aphasia rehabilitation process (Helm-Estabrooks, 2002). The majority of people who experience a stroke also present with cognitive impairments whether aphasia is present or not (Hoffman, 2001). These difficulties remain highly prevalent up to three years post-onset (Patel, Coshall, Rudd and Wolfe, 2003), impacting upon the development of treatment plans and the anticipated outcomes of aphasia rehabilitation (Helm-Estabrooks, 2002). The rehabilitation of language and its impact upon recovery has already been addressed above (see section 2.6.3.1). While visuo-spatial skills may impact upon the type of therapy materials used in rehabilitation they are not considered influential on the recovery of language itself. Therefore, the remaining three cognitive processes will be discussed below: attention, memory and executive function.

There is increasing evidence that impairment to the process of attention may either be a part of or co-exit with aphasia (Murray, 1999), interacting with language processes and thereby contributing to communication impairment (McNeil, Odell, and Tseng, 1991). Attention is thought to “gate” the processing of information in visual, auditory and somatosensory perception (Robertson and Murre, 1999), where the brain selectively pays attention to experiences it expects, incorporating them through learning into its knowledge of the world (Grossberg, 1999). Vakil, Hoffman and Myzliek (1998) studied the effects of active and passive learning in adults and reported that individuals who participated in active training performed better and retained more durable memory traces than those who participated in passive training. Therefore as previously discussed (see section 2.5.2), cortical plasticity occurs with the acquisition of new information which requires attention and continuous practise, therefore neuronal reorganisation is not a passive process but requires active attention during the task.

As Helm-Estabrooks (2002) asserts, aphasia therapy is a learning process and adequate memory processes are required to remember the newly learned information. Memory processing impairments are common following a stroke (Murray, 2004, 2002; Skeel and Edwards, 2001; Burgio and Basso, 1997; Wilson and Hughes, 1997 and Ween, Verfaellie and Alexander, 1996) and therefore are often experienced by people with aphasia. However, memory processing difficulties are not thought to be associated with specific lesion sites and often persist despite good language recovery (Ween et al., 1996). Impairment can occur at any of the three processing stages – encoding (involving acquisition and consolidation of information), storage (creation and maintenance of permanent records of information) and retrieval (employing the previous stages to create a representation of the memory) (Parkin, 2001; Robertson, 1999).

Purdy (2002) reports that communication impairment in people with post-stroke aphasia may also involve executive function difficulties. While it is generally thought that executive functions exist mainly in the frontal lobe regions of the brain, they are supplied by the middle cerebral artery a common locus of stroke (Callahan, 2001). Glosser and Goodglass (1990) reported that people with aphasia present with executive impairments particularly evidenced by the presence of perseverative errors. Purdy (2002) suggests that people with aphasia demonstrate reduced executive abilities by being unable to initiate, plan, monitor and correct their own communicative performance. The effects of executive dysfunction may interact with or amplify communication limitations due to aphasia, further limiting the ability to communicate (Keil and Kaszniak, 2002). In fact it has been suggested that these functions may be fundamental in the complex task of communication, which involves sequencing, monitoring, (Ramsburger, 2000), problem solving and goal orientation (Helm-Estabrooks, 2002).

Additionally, there is a strong relationship between depression and cognitive processes, with depression causing reversible cognitive impairment (Spalletta et al. 2002; Kimura, Robinson and Kosier, 2000; Kauhanen et al., 1999; House, Dennis, Warlow, Hawton, and Molyneaux, 1990) (see section 2.6.3.2). Bolla-Wilson et al. (1989) demonstrated that left hemisphere stroke patients with major depression had significantly greater cognitive impairments than people with left hemisphere lesions but no depression. The cognitive processes likely to be impaired are memory, non-verbal problem solving, attention and psychomotor speed (Kauhanen et al., 1999). Anxiety disorder was found not to effect cognitive processes, however people with depression and anxiety had greater impairment in activities of daily living than with depression alone with the period of depression being significantly longer and more severe (Shimoda and Robinson, 1998).

Cognitive processes are complex and interrelated but their interactive relationships (for example, between attention, memory and executive function) are not clearly defined (Purdy, 2002). These processes are considered to be factors that impact upon the rehabilitation process of aphasia. The acquisition of information/ knowledge requires active participation to promote and facilitate cortical plasticity. If a person is unable to attend to the rehabilitation stimuli being presented they will fail to adequately process the information. As aphasia therapy involves the acquisition of information, methods and skills (similar to the learning process), memory processes must be intact to retain information or strategies learned (Helm-Estabrooks, 2002). Additionally, the presentation of post-stroke depression alongside aphasia further impacts upon a person's cognitive ability and consequently their ability to participate in and benefit from aphasia rehabilitation. Kimura et al. (2000) suggest that the treatment of post-stroke depression may be one of the most significant methods of promoting cognitive recovery.

2.6.4 Rehabilitation of language impairments

2.6.4.1 Intensity and timing of language rehabilitation

The efficacy of language therapy intervention has already been discussed (see section 2.4.1), however the results from some studies have observed an association between intensive therapy and improved aphasia outcomes (Bhogal, Teasell and Speechley, 2003). Poeck et al.'s (1989) findings indicated that language recovery progressed as a result of intensive therapy even in the chronic phases of recovery. Additionally, Roby's (1998) meta-analysis reports that people receiving high intensity aphasia rehabilitation recover twice as great as those not receiving any therapeutic input. Conversely, where only low intensity aphasia rehabilitation was provided, improvement was only slightly greater than for those not receiving any therapeutic input. Pulvermüller et al. (2001) also concluded that the intense provision of their treatment procedure (constraint-induced aphasia therapy) provided a better outcome than the same amount of conventional therapy provided over a longer time period. Brindley, Copeland, Demain and Martyn (1989) also report that intensity of language intervention showed significant improvement whereas periods of non-intensive therapy resulted in no significant improvement. The intensity of aphasia therapy intervention can therefore be considered an influencing factor in the recovery of language. Unfortunately in many instances there are staffing and financial constraints in offering this mode of therapy and Brindley et al. (1989) assert that it is only when the current health system is reorganised by increasing resources (with an increased allocation of time to speech and language therapists) will aphasia therapy be effective, particularly for those people who present with chronic aphasia. Robey's (1998) meta-analysis demonstrated that people should be seen as soon as possible after a stroke – when treatment was given at post-acute stages the average effect size for individuals was smaller than for more chronic aphasia but was still 1.68 times more than those who did not receive any language therapy. Additionally, those in the chronic stages of recovery also showed more change when treated compared to those who were untreated. Outcomes were also reported to be greatest when treatment is begun in acute stages of recovery (Robey, 1998).

2.6.5 Summary

The above studies, while not exhaustive, indicate the various factors that have been considered to impact upon the recovery from aphasia. Pre-morbid factors such as age and education have provided equivocal results. However many studies have employed different methods of assessing the impact of these elements on the recovery of aphasia and therefore it is difficult to compare outcomes. Biological limitations have also been discussed and the size and site of lesion are thought to be intrinsically linked with the initial severity of the language impairment. A further impacting factor on recovery appears to be the initial functional severity of a number of variables following the stroke. These include the initial severity of aphasia, which appears to be the most strongly supported impacting factor on recovery. Emotional disturbances following a stroke (especially post-stroke depression) also impact upon the performance of an individual and puts the person at risk of further cognitive difficulties. Cognitive impairment (in particular, attention, memory and executive function) is a complex factor that often co-exists with aphasia and can impact upon its recovery.

The rehabilitation process also has a part to play in determining recovery of language. As discussed, although aphasia therapy is considered to be efficacious (see section 2.4.1) the process underpinning rehabilitation is not fully understood. However, the intensity of rehabilitation and its timing are factors that have been shown to impact upon the recovery process (see section 2.6.4). As various efficacy studies have employed different methods for assessing initial aphasia severity, different stimuli and therapy procedures for rehabilitation and also various measures of outcome and recovery, it is not clear exactly what part of the therapeutic process causes or facilitates the recovery of language function. Even when people receive the same therapeutic intervention they do not always appear to have the same outcomes (Best and Nickels, 2000). If therapists are to adopt the best rehabilitation methods, eliminating ineffective ones that promote maladaptive connections (Enderby and Emerson, 1995), the processes underlying rehabilitation must be investigated.

2.7 CURRENT THEORETICAL ACCOUNTS OF LANGUAGE REHABILITATION

Byng and Black (1995) advise that the current working practice of speech and language therapists involves the assessment of an individual's particular manifestation of aphasia. The data are then interpreted in terms of models of normal language processing, thus enabling hypotheses to be made about the specific nature of the person's aphasia. Speech and language therapists have the use of information processing models such as those based on the cognitive neuropsychology approach, which has established the normal stages and pathways involved in single word comprehension and expression (Ellis and Young, 1996). The cognitive neuropsychological model of single word processing is a static model on which a person's language abilities may be mapped and impairments may be highlighted at any one moment in time. It developed from studying dissociations between single case studies of people with impairments in different areas of language functioning (Ellis and Young, 1996). Language assessments have since been developed which aim to target the various modules and pathways of this model such as the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) (Kay, Lesser and Coltheart, 1992) (see Appendix 2.1 for examples). This enables the therapist to establish which spoken and written language functions are impaired, thereby guiding them to the area of aphasia that requires rehabilitation. This tool also enables therapists to record change following therapy where abilities/ impairments again may be mapped on this model for comparison to pre-therapy baselines.

The rehabilitative process continues with the development of language therapy programmes in order to provide structured experience-dependent learning that facilitate language recovery. However although the language impairment can be identified, Howard and Hatfield (1987) assert that this information does not determine which precise therapy programme is the most appropriate to target a particular area. As the information processing models prove useful in identifying where therapy should target, a model of rehabilitation would similarity prove invaluable in determining the exact nature of therapy to use for a given impairment. To date however there is not yet a model or theoretical account that explains the dynamic therapist-patient interaction (Horton and Byng, 2000), what therapy actually is or the process involved in rehabilitating the damaged language component(s). In order to develop this theoretical account/ model of rehabilitation additional questions need to be addressed to determine how therapy works and to clarify what therapy is aiming to achieve (Byng, 1993) which in turn may help define exactly what therapy is (Basso, 1989).

Ferguson (1999) discusses models of aphasia therapy that were identified by Horner, Loverso and Rothi (1994) and asserts that their specification does not inform us as to HOW the therapy process targets the impaired language function and achieves its outcomes. Speech and language therapists in the United Kingdom have begun to address what therapy is aiming to achieve through making the decision-making process of rehabilitation more explicit, overtly stating the aims (e.g. rehabilitative, curative, enabling) and goals of therapy, specifying tasks chosen to assess and treat people and the provision of evidence of therapy outcome (Malcomess, 2001; McCarthy, Lacey and Malcomess, 2001). However that process which guides the judgement of the speech and language therapist in choosing the actual form of the therapy is still not explicitly addressed (Byng and Black, 1995) and in contrast to theories about impairments, theories about the therapy process still remain largely under developed (Byng and Black, 1995). Currently therapists rely on their own and other therapists' experience, skill and clinical judgement in choosing tasks and procedures to target identified language impairments (Wilson and Patterson, 1990). While these have been proven to be effective on the whole it is not possible to discern which approaches or tasks will be successful in rehabilitating which particular aspects of aphasia (Best and Nickels, 2000). Additionally, as previously discussed (see section 2.4.1), it is not currently understood why some people with apparently similar characteristics of aphasia do not always gain equal restitution of language function (Best and Nickels, 2000). Davis (1993) suggests that there are four different levels at which to target treatment goals: behavioural, general cognitive, specific cognitive and neurological and that language rehabilitation addresses all but the neurological level. However, this should not be the case as language rehabilitation involves cortical plasticity (see section 2.5.4) and the importance of avoiding maladaptive connections has already been discussed (see section 2.5.4). In order to fully investigate the process of recovery from aphasia any theory of rehabilitation would have to address the neurophysiological level of the recovery process (Gordon, 1999).

Ferguson (1999) states that only when the underlying process of language rehabilitation is ascertained and understood can it be appraised and improved. The constraints to this process may then help identify why some people are more amenable to rehabilitation than others (Howard, 1999). Where does one begin when trying to establish a theoretical account of therapy that identifies the underlying process(es) in language rehabilitation? The application of some prominent theories of learning could be applied to aphasia rehabilitation as they incorporate conditions that are necessary for shaping adaptive behaviours while extinguishing maladaptive behaviours, thus instating or reinstating neural pathways (Ferguson, 1999). Howard (1999) argues that the use of theories of learning is not enough in itself but agrees that in order to explain the theory of therapy the process of aphasia rehabilitation may involve different kinds of learning at various stages of recovery. He states that any theory of therapy would also have to address the question of how the process is effective in relation to the presentation of the language impairment.

As indicated, any theory of rehabilitation would involve an interaction of the complexities of the brain's normal response to damage (including cortical reorganisation); various theories of impairment and therapy; optimal timing; the procedures and stimuli used during therapy; the prevention of maladaptive connections and the agreement of terminology (Ferguson, 1999; Boyle, 1999; Gordon, 1999; Howard, 1999; Linebaugh, 1999). One first step could be to establish if the rehabilitation of language involves facilitating the access of previously inaccessible memory traces for example, already held vocabulary. This relates to Schuell, Jenkins and Jiminez-Pabon's (1964) proposal that the aim of therapy is to maximise the efficiency of an impaired language system rather than teach new materials. Alternatively, it is possible that language therapy involves a process of new learning where new neuronal connections and pathways are being formed. This information would indicate the possibility that rehabilitation could be a facilitator of new learning or merely a means of accessing previously known and now inaccessible information or memory traces due to post-stroke damage or both. If it is demonstrated that people with aphasia can learn new vocabulary then it is likely that the underlying process of therapy could involve new learning, which in turn involves related cortical reorganisation (see section 2.5.2). If new learning could be the underlying process of aphasia rehabilitation it would be beneficial to look at theories of learning and approaches as a possible means for explaining therapy. Ferguson (1999) asserts that the significant learning process involved in aphasia therapy needs to be identified.

If new learning was found to be involved in the rehabilitation process it would also have implications for the tasks and procedures employed in language rehabilitation. Consequently, the best methods of learning would need to be established to ensure that the therapeutic process would guide neurones in making correct rather than faulty connections thereby facilitating and enabling recovery of function. To achieve these neuronal connections specific and accurate therapy must be engaged in repeatedly in order that the brain can re-learn the previously learned/ known pattern of connections that underpin the particular skill being targeted (Robertson, 1999; Robertson and Murre, 1999).

Additionally, harmful or redundant therapy tools/ methods that could promote maladaptive neuronal connections could be eliminated. It is also possible that both processes could be happening simultaneously during the therapeutic process i.e. formation of new representations and accessing already held representations. If a theory of rehabilitation incorporated theories of learning then it would be important to identify any constraining factors impacting upon this new learning experienced by people with aphasia. It is possible that those identified constraints on learning could also be the same factors that are thought to influence language recovery (see section 2.6). Additionally, as people are thought to learn in different ways it may be that different learning techniques would facilitate language restitution in different individuals.

However it has not yet been adequately proven that new learning is occurring during the therapeutic process. Gordon (1999) highlights the problem of various terminologies within learning theories, however, it must first be established that new learning is occurring in therapy. In order to address this it must first be established that people with aphasia can demonstrate new learning despite language impairment. This investigation intends to address this question. However, in order to ensure that the investigation measures the ability of participants with aphasia to learn new language-related information rather than accessing old memory traces through other methods, their ability to learn new vocabulary will be assessed (i.e. the acquisition of new knowledge incorporating novel words). If adults with aphasia are unable to demonstrate the learning of new vocabulary then it suggests that aphasia therapy facilitates the re-accessing of previously known information. Therefore, the tools and methods used in language therapy sessions should reflect this. If however, adults with aphasia demonstrate that they can learn new vocabulary then the therapy tools and methods could incorporate novel methods to facilitate this new learning (e.g. can we teach the old words as new words encouraging new pathways to be laid down?). As previously discussed (see section 2.5 and subheadings) learning or acquiring new skills, information and vocabulary implies laying down new synaptic connections i.e. plasticity in a damaged system or the brain utilising an unused part of the brain. The ability of the adult brain to learn or acquire new skills and information has been discussed (see section 2.5.2). The next section will discuss specifically some of the characteristics of vocabulary that will inform the stimuli for the main investigation (i.e. word forms, word meaning and grammatical behaviour). Current evidence for learning vocabulary by healthy adults and adults with post-stroke aphasia will be discussed.

2.8 LEARNING VOCABULARY

There is much evidence that we begin to learn even before we are born. The neonatal infant recognises its mother's voice over other voices as soon as it is born because it has been hearing its mother's voice for several months before birth (Fifer and Moon, 1994). After birth the brain continues to develop and what a child learns and experiences is reflected in the neuronal patterns and connections of their brain (Robertson, 1999). Here too the acquisition of language begins. From the day a child is born it begins to learn to communicate using speech, gesture and later writing (Nation, 1995). For the purpose of this investigation the focus will be on what is termed as the basic element of language – vocabulary, i.e. the range of words known to a person (Fowler and Fowler, 1990), which consists of connections between each word's form and meaning (Black and Chiat, 2003). There is not yet a complete theory of how vocabulary is learned by children and many studies have investigated the size and growth of a child's vocabulary rather than the acquisition process itself (Schmidt, 1998). As adults this acquisition of knowledge continues, resulting in cortical reorganisation that occurs due to new neuronal patterns being created (see section 2.5.2). A representation of each word that is learned is thought to be stored in a type of mental dictionary called a lexicon, which contains all information about a word (Harley, 2001). Each word that is learned is thought to contain a number of levels of information such as the word form (the combination of sounds – phonology, and letters used for spelling – orthography); the conceptual meaning(s) of each word and its associations to other known words (semantics) and the grammatical behaviour of each word (nouns, verbs and role of the word in a sentence) (Nation, 1995). The basic representations of vocabulary will now be briefly described.

2.8.1 Word form

The representation of the word forms of vocabulary consists of the combination of individual sounds which divide into rhythmical units forming syllables. The word forms consist of the acoustic form of speech sounds (auditory) and how they are articulated (spoken) (Harley, 2001). It was previously suggested that a word's phonemes were stored separately and each time the word was spoken it had to be reformed sound-by-sound (Becker, MacAndrew and Fiez, 1999). However current evidence suggests that it is more likely that the phonological shape of a word, familiar through repetitive use, would be stored in for example syllable form and does not need to be reconstructed each time the word is produced (Levelt, Roelofs and Meyer, 1999). There has been much discussion regarding whether there is one lexicon that facilitates the access of four modalities – listening, speaking, reading and writing, when retrieving a word or whether there are four discrete lexicons, one for each modality. Evidence from error analysis in cognitive neuropsychology indicates that the mental lexicon is fractionated with a separate lexicon for each modality (see Ellis and Young, 1996; Kay et al., 1992). The production of words is considered to be a staged process beginning with the concept or idea to the retrieval of the word's phonological shape from the lexicon (Levelt et al., 1999). In normal speech we recall two to three words per second from our lexicon that is thought to contain many thousands of words (Levelt et al., 1999). Word form errors are produced by healthy individuals (slip-of-the-tongue phenomena) occurring in just one per thousand words according to Levelt et al. (1999). Word form errors are also often produced by people with aphasia but on a more regular basis often affecting the communication of their message. Similar to healthy adults word form errors have similar phonetic characteristics to the target word. Such errors are phonotactically legal in that they do not contain sequences that are not found in their native language (Nickels, 2001).

2.8.2 Conceptual meaning of words

The representation of the meaning of a word is held in the semantic system. It is generally agreed that the semantic system contains all of our concepts, meanings, images and the associations we have linked to them (Robertson, 1999). New information is encoded into our memory by describing it in terms of what is already known and its semantic relations to already held representations (Bjork and Bjork, 1996). Just as the lexicon is the mental dictionary the semantic system is our mental encyclopaedia where we tend to categorise knowledge and concepts (Daniele, Giustolisi, Silveri, Colosimo and Gainotti, 1994) by for example, perceptual (shared function – for example, sofa and chair) or biological features (for example, fruit or vegetables) (Harley, 2001). There is also evidence for hierarchical relations between categories for example, a basic level (cat), a superordinate level (mammal) and a subordinate level (Persian). The semantic system also contains associations between words that regularly occur together (for example, bread and jam), words with similar meanings (for example, yacht and ship) as well as connotations relating to the words (for example, a cat can be cuddly or scary) (Harley, 2001). Research has provided evidence that the meaning of a word can be dissociated from the word form therefore a word can be spoken or read without knowing its meaning (Ellis and Young, 1996; Kay et al., 1992). However the naming of an object or picture without semantics is not possible, therefore one can only name an object when the semantic information attributed to that object is available (Hodges and Greene, 1998). Studies have provided evidence for loss of semantic information (as in semantic dementia) as well as difficulties accessing representations stored in the semantic system (word-finding errors from people with aphasia). As with the lexicon there has also been much discussion about how many semantic systems there are. The interpretation of the presentation of semantic category-specific deficits in some people with brain damage is controversial (Caramazza, 1998). Studies have reported dissociations, in particular between animate and inanimate objects (Warrington and Shallice, 1984; Silveri and Gainotti, 1988) and living and non-living things (Warrington and McCarthy, 1983; Hillis and Caramazza, 1991). There are those who advocate the unimodal semantic system (for example, Caramazza, Hillis, Rapp and Romani, 1990; Hillis, Rapp, Romani, and Caramazza, 1990) where there is one central store of meaning that can be accessed by all modalities. Others advocate multiple semantic systems as evidenced by category-specific semantic disorders. However Capitani, Laiacona, Mahon and Caramazza (2003) reviewed evidence in favour of category-specific deficits and reported that the existence of reliable cases which could indicate multi-semantic systems was not very strong.

2.8.3 Grammatical behaviour of words

Inherent in words are different grammatical markers, which indicate how a word should be used within a given sentence – nouns (words for objects), proper nouns (words naming people or places), verbs (words describing actions) and function words (for example, he, she, the). Although not universally accepted, category-specific deficits have also been described for grammatical classes of words such as verbs and nouns (Daniele et al., 1994). Some investigations have suggested that they are dissociated anatomically (Daniele et al., 1994) and functionally as people with aphasia often have more difficulty retrieving verbs than nouns (Breedin, Saffran, and Schwartz, 1998; Caramazza and Hillis, 1991) suggesting that these word classes behave differently. Warburton, Wise, Price, Weiller, Hadar and Ramsay (1996) also found dissociations between verbs and nouns with healthy people from PET scans. However, no differences in neural representations as a function of word class was found in Tyler, Russell, Fadili and Moss' (2001) PET scan investigation with healthy people. They did report however that verbs with inflections were more difficult to retrieve than nouns with inflections. Dissociations between proper and common nouns following brain damage have also frequently been reported, questioning if the different word classes are processed by distinct mechanisms (Robson, Marshall, Pring and Montagu, 2004). It is generally agreed that proper nouns are processed differently both neuropsychologically and anatomically than common nouns in the brain with proper nouns being considered to be labels attached to referents and thus without semantic meaning (Schmidt, Buchanan and Semenza, 2004; Yasuda, Nakamura and Beckman, 2000; Lyons, Hanley and Kay, 2002; Miceli, Capasso, Daniele, Esposito, Magarelli and Tomaiuolo, 2000). Robson et al. (2004) report that the production of proper nouns were significantly more difficult to name than common nouns but the comprehension of both word classes were high with no class effect.

2.8.4 Summary and implications

The above brief description of the representations of vocabulary indicates some controversy in the interpretation of evidence for the number of lexical and semantic systems as well as the behaviour of different word classes. This investigation will assume the existence of four lexicons – one for listening, reading, speaking and writing in accordance with the cognitive neuropsychological approach (Ellis and Young, 1996; Kay et al., 1992). There appears to be more evidence and support for a unimodal semantic system where all modalities access the meaning and associations of words (for example Capitani et al., 2003; Caramazza et al., 1990; Hillis et al., 1990). Therefore this investigation will assume the existence of one central semantic system relating to the cognitive neuropsychological model (Ellis and Young, 1996; Kay et al., 1992). Controversy also exists for the behaviour and location of word class with verbs being considered more difficult to process than nouns by some researchers (Breedin et al., 1998; Warburton et al., 1996; Daniele et al., 1994; Caramazza and Hillis, 1991). Dissociations have also been observed between proper nouns and common nouns (Robson et al., 2004) with common nouns being seen as having more semantic depth (Schmidt et al., 2004; Lyons et al., 2002; Miceli et al., 2000; Yasuda et al., 2000). Therefore in order to avoid difficulties arising in data interpretation due to word class, this investigation will select only one word class for its stimuli. Nouns by their very nature are more concrete and imageable than verbs therefore nouns will be used for this investigation. As learning new words involves making associations with already known vocabulary, it was thought that words with more semantic depth would facilitate this learning. Thus common nouns were chosen over proper nouns which are thought to lack this depth. The word class of the new vocabulary stimuli for the main investigation will therefore include common nouns only. The stimuli will be discussed later in section 2.9.1.

2.8.5 Current evidence for learning new vocabulary

Howard (1999) states that the course of recovery of aphasia cannot be equated with language acquisition; however as there is no current theory of aphasia rehabilitation it is not known if the processes used in language acquisition are utilised in aphasia therapy. It is therefore essential to investigate the ability of adults (both with and without cortical damage) to learn new vocabulary. The studies discussed below involve the demonstration of vocabulary learning by healthy adults with no history of brain damage, people with memory impairment and also people with post-stroke aphasia.

2.8.5.1 Healthy adults learning vocabulary

There have been a small number of studies evaluating various learning techniques for adults acquiring new vocabulary. Some of these investigations employed learning unfamiliar words. Others observed the learning of a foreign language and yet others used nonsense or non-words to observe vocabulary learning.

A small number of studies have employed the use of vocabulary in the native language of participants that was considered to be unfamiliar to them, as a method for observing learning. Freed, Marshall, and Phillips' (1998) investigation involved 30 adults learning to match 20 colour photographs of unfamiliar breeds of dogs with their names and evaluated the success of semantic and phonological cueing in an over-learning technique. Downes, Kalla, Davies, Flynn, Ali and Mayes (1997) also employed native language vocabulary in the form of surnames, which were extracted from the phonebook and paired with photographs of people who were unfamiliar to participants. They evaluated the effectiveness of two techniques (separately and combined) in facilitating the learning of matched pairs - the 'pre-exposure' technique and the imagery technique (see section 2.8.5.2). The pre-exposure technique involved the presentation of the photograph (face) alone to participants, without giving further information or requiring a response, prior to presenting the associated name. This aimed to provide a representation of the stimuli before introducing further information. The imagery technique involved capitalising on the high imageability of the names, which were chosen specifically for this purpose. Participants were offered a mental mage for each face-name pair in an attempt to assign meaning to the arbitrary labels (in this case surnames), for example, they were told to imagine Mr. Fox as having a bushy tail in place of his nose (Downes et al., 1997). The results indicated that the pre-exposure technique alongside the imagery technique produced significantly greater results than either technique alone for learning and recall. The authors assert that the pre-exposure technique is involved in the encoding and storage/consolidation of material and when combined with the imagery technique produces significant gains in learning performance.

As many adults have acquired a wide vocabulary in their native language (L1) since childhood, second language learning (L2) offers the opportunity to evaluate the learning of new vocabulary in adulthood. Van Hell and Mahn's (1997) investigation compared the success of employing two learning techniques - keyword mnemonics (KM) and rote rehearsal (RR) – by healthy adults. Keyword mnemonics involved an elaborate creation of an association between the L2 and L1 word, for example, if Dutch L2 keyword = paint, L1 word = paard (sounds and looks similar to keyword), L1 translation = horse. A mental image in which the words interact could be visualising a horse carrying a paint pot on its back (van Hell and Mahn, 1997). Rote rehearsal simply involved memorising and repeating the new words silently and then with it's paired translation. Both KM and RR learners recalled the same number of items with KM learners requiring more time to recall the vocabulary. The authors suggest that KM involves the creation of an interactive image between the target word and their native language translation but query its use with inexperienced second language learners. Lotto and de Groot (1998) also evaluated the ability of healthy adults to learn new vocabulary comparing the presentation of the L2 word with its native language translation, with the presentation of L2 with its pictorial representation alone. The results indicated that participants demonstrated better learning when from the L1/L2 word presentation than with L2 and picture representation alone. They also reported that cognates (i.e. share parts of orthographic and /or phonological form with translation) and high frequency words were easier to learn than non-cognates and low frequency words.

A number of investigations have employed nonsense or non-words to evaluate how healthy adults learn new vocabulary. De Groot and Keijzer's (2000) investigation paired native language words with non-words using a paired-association technique. The results indicated that cognate words were easier to learn than non-cognates and also less easily forgotten (as assessed one week after training). Unlike Lotto and de Groot's (1998) investigation, they found that word frequency had very little effect on performance. In addition, the results observed that participants demonstrated better recall when assessed on comprehension rather than production tasks and the words that were initially easy to learn also left more permanent memory traces. The authors assert that the results indicate that concerns that participants might not be motivated to learn nonsense material is not warranted. Basso, Marangolo, Piras and Galluzzi (2001) also evaluated the ability of healthy adults to learn to match 30 paired bi-syllabic non-words and pictures, employing repetition, reading aloud and orthographic cueing to facilitate learning. They report that orthographic cueing was significantly more successful than the other two methods.

As we continue to learn throughout our lives and acquire new information and vocabulary as we participate in education and learn new skills for employment and leisure pursuits, it would be expected that healthy adults would have little difficulty in learning new words. However for this investigation it is important to review those studies that incorporate the learning of vocabulary by people who have acquired brain damage. While many people with aphasia also present with memory processing difficulties following a stroke (see section 2.6.3.3) it would be useful to ascertain if people with memory processing impairments alone are able to demonstrate new learning. If not, any difficulty learning new vocabulary by people with aphasia could be due to memory processing impairments rather than language difficulties alone. The following studies investigate new learning with memory-impaired participants.

2.8.5.2 Adults with memory impairment learning vocabulary

A small number of investigations have been carried out with people who present with memory impairments to assess their ability to learn new vocabulary and evaluate the best methods to facilitate this learning. Downes et al., (1997) included memory impaired participants (due to brain injury) in their study with healthy individuals as mentioned above (see section 2.8.5.1). The investigation involved photographs of people unfamiliar to the participants and they learned to pair these photographs with surnames randomly taken from a phonebook. As with healthy participants the investigation indicated that the pre-exposure technique alongside the imagery technique facilitated significantly greater learning and recall. Kalla, Downes and van den Broek (2001) also used surnames from a phonebook and photographs of people unfamiliar to the participants. Their study evaluated 'errorless' learning versus 'errorful' learning using the pre-exposure technique. Additionally, they required the participants to make judgments about each of the people in the photographs, (for example, if they looked honest, diligent, friendly, honest etc.). Their results indicated that like Downes et al.'s, (1997) investigation, the pre-exposure technique was a necessary component to learning because it provided a staggered learning process where the image of a person's face was first established before the associative component (in this case a name) was superimposed. Additionally, they assert that in order that this pre-exposure technique be beneficial to the learning, it must be used in conjunction with an efficient mnemonic strategy, which this study used evaluative judgments by participants. Another study employed the use of foreign vocabulary in evaluating the ability of a severely amnesic participant in learning new vocabulary, incorporating recognition and recall of the words (Van der Linden, Cornil, Meulemans, Ivanoiu and Salmon, 2001). The results indicated that despite the severity of his memory impairment, the participant was able to acquire this vocabulary and his learning ability was similar to control participants. A number of other studies evaluated the ability of people with memory impairment due to dementia in learning new vocabulary / information. Arkin, Rose and Hopper (2000) claimed evidence of implicit and explicit learning with dementia patients as well as semantic activation with pre-morbidly learned knowledge. Swales and Johnson (1992) had also reported that their participant with semantic dementia was successful at re-acquiring previously known verbal information but he was unable to learn new verbal concepts.

These studies although small in number indicate that some memory-impaired people are able to demonstrate learning (in particular those people who have acquired amnesia through trauma), however, it may not be the case for all individuals (in particular, people with progressive memory impairments). As previously discussed, aphasia from a stroke is sudden in onset and not progressive in nature (see section 2.2), therefore any acquired memory impairment could be assumed to be more similar in nature to memory impairment from trauma rather than dementia. Findings from this population suggest that this type of memory processing difficulty would not prevent new learning. The following investigations evaluate the evidence of new learning with people with aphasia.

2.8.5.3 Adults with aphasia learning vocabulary

There have been a small number of studies evaluating the ability of people with aphasia to learn new words. Similar to studies with healthy and memory impaired adults various techniques have been employed to evaluate learning. Some of these studies have utilised real words that were unfamiliar to the participants to demonstrate the learning of vocabulary. Grossman and Carey (1987) report that in the 1970s several researchers attempted to teach new words to people with aphasia but failed to demonstrate any ability on the participants' part to acquire new words. Grossman and Carey's (1987) own study aimed to evaluate their participants' knowledge of one word (bice) that was considered to be unknown to them. The results indicated that while many of their participants demonstrated some learning they presented with varied learning profiles, which the authors suggest is synonymous with their individual presentation of aphasia. They demonstrated that people with Broca's and fluent aphasia presented with very different learning abilities for the new word. Basso et al. (2001) evaluated the ability of two participants with aphasia to re-acquire vocabulary using techniques employed with healthy adults (see section 2.8.5.1). Results indicated that participants did not learn all the target words but were able to demonstrate some learning. As with healthy adults the orthographic cueing method promoted significantly higher recall and learning. They advise that although additional time for recall of the learned items did not help healthy adults recall more information it may be an important factor for people with aphasia. Marshall, Freed and Karow (2001) evaluated two cueing techniques to facilitate learning – personalised cueing and phonological cueing – using the names of unfamiliar breeds of dogs matched with photographs of the dogs. Results indicated that participants who learned the associations using personalised cueing had significantly higher levels of naming accuracy and recall than phonological cueing.

Other studies evaluated learning using familiar words matched with novel abstract symbols, which reduced bias from previous learning. Marshall, Neuburger and Phillips (1992) evaluated the facilitation technique (non-verbal word-to-symbol matching tasks) and cueing technique (repetition and sentence completion tasks) with people with mild-moderate aphasia. Results indicated that participants were able to learn new paired associations using both techniques. The authors assert that learning using the word-symbol matching technique required a deeper level of processing than repetition as it involved deeper semantic processing. They also advise that provision of the opportunity for rehearsal is important in assisting the transfer of newly learned items from short-term to long-term memory. Freed, Marshall and Nippold (1995) also used the matching of familiar words with abstract symbols and evaluated the effects of personalised cueing (where participants created their own unique cue for the symbol) versus cues provided by the researchers. Unlike Marshall et al.'s (2001) findings their study concluded that both methods of cueing were comparable in facilitating correct responses for up to 30 days following training.

These studies indicate that people with aphasia have the potential to learn new word associations albeit to varying degrees. The learning studies will be summarised below, incorporating a discussion on the various learning techniques and methodological issues that were relevant to this current investigation.

2.8.6 Summary of learning studies

The above studies provide evidence that people with aphasia have the potential for new learning. Various learning techniques have been evaluated with healthy adults, people with memory impairments and also people with aphasia to determine the optimum methods of acquiring new vocabulary or information. The investigations identify a number of factors influencing this learning. Firstly, active participation in the learning process produces better memory retention than passive observation (Basso et al. 2001; Vakil et al. 1998). For example, the imagery technique involves active interaction with the words to be learned (Downes et al. 1997) and the orthographic cueing technique is more successful than more passive strategies such as repetition or reading aloud (Basso et al., 2001) as is keyword mnemonic learning over rote learning (Van Hell and Mahn, 1997). Secondly, the pre-exposure technique is considered a significant factor involved in the encoding and storage/consolidation of new vocabulary. When combined with the imagery technique it produced significant gains in the learning and recall of new words (Downes et al., 1997). Cognate words were demonstrated to be more easily learned than non-cognate words (de Groot and Keijzer, 2000; Lotto and de Groot, 1998). Additionally, the presumption that healthy adults could not be motivated to learn non-words was dismissed (de Groot and Keijzer, 2000).

However, a major methodological issue surrounds these studies when considering the learning of vocabulary. While the studies investigated the ability of people with aphasia to learn, none of these studies investigated the learning of new vocabulary where both the word form and word meaning was novel. A number of the studies employed already held phonological representations, for example, use of surnames (Downes et al., 1997), dog breed names (Marshall et al. 2001; Freed et al., 1998) or familiar words (Freed et al., 1995; Marshall et al. 1992; Grossman and Carey, 1987). Other studies used novel word forms (non-words) with already held semantic representations – pictures of familiar objects (Basso et al., 2001; Lotto and de Groot, 1998; Van Hell and Mahn, 1997). Therefore, the question of whether the damaged adult linguistic system is capable of acquiring new vocabulary involving new word forms and word meaning/concepts still remains to be investigated. As previously discussed (see section 2.7), the actual mechanism underlying the improvement of language disorders is largely unknown. Speculation includes the possibility that the person is accessing inhibited memory traces that require re-exposure to the 'forgotten' items for reinstatement (Bjork and Bjork, 1996). However, another alternative hypothesis is that new learning is taking place during the rehabilitation process. Current knowledge of therapeutic intervention does not differentiate between therapy that reactivates existing representations or processes and therapy that leads to the acquisition of new representations and processes. Knowledge about whether the damaged linguistic system is able to acquire new information will also inform any theory of rehabilitation and that of related brain plasticity and cortical reorganisation. Therefore, this investigation aims to address this question and evaluate whether people with aphasia can demonstrate the learning of new vocabulary (i.e. new word forms with new meanings) despite having language impairment. As this study is pioneering in the field of aphasia rehabilitation the methodology had to be created. In order to do this a number of issues were addressed and are discussed below.

2.9 CONSIDERATIONS FOR INVESTIGATING NEW VOCABULARY LEARNING

As this is a new type of investigation there are no others available for replicating methodology, training procedures or outcome measurements. Each of the studies discussed above (see section 2.8) involved different stimuli, various learning techniques and procedures, had different learning criteria and measurement of the demonstration of learning. Therefore the methodology was created utilising the most appropriate findings from existing learning studies. The creation of the stimuli, the use of optimal learning techniques and an appropriate model of language processing to facilitate the assessment and evaluation of the new learning will now be discussed.

2.9.1 Stimuli

Previous studies have used either non-words with already familiar concepts as meanings or real word forms with abstract symbols as paired concepts (see section 2.8.5 and sub-sections). In order to evaluate the ability to learn new vocabulary it must be proven that each participant had no previous memory trace of either the word form or meaning. To ensure this the new or novel vocabulary had to be created. There is some indication that verbs and nouns are processed differently (see section 2.8.3) and some studies have reported that people with aphasia appear to retrieve nouns more easily than verbs (Breedin et al. 1998), therefore in order to facilitate learning and retrieval of new vocabulary the new words will be designed to operate as nouns. Additionally, common nouns and proper nouns appear to operate differently (see section 2.8.3) with proper nouns acting more like labels associated with a referent without semantic meaning. Theories of learning suggest that new vocabulary is acquired by forming associations with already held words or concepts making them more meaningful (Levelt et al., 1999). Therefore the new vocabulary must also be designed to be associated with already familiar words, and nouns are considered to be more appropriate for this purpose. The number of words trained in previous studies varied widely, as did the number of letters and syllables in each word, therefore there is no guidance available as to the best format of the word forms except to ensure that they are as pronounceable as possible and legal to the native language of participants.

2.9.2 Optimal learning techniques

In order to facilitate the demonstration of any new learning the literature was further reviewed to evaluate suitable techniques for learning, retaining and retrieving new information. Optimal learning techniques were then developed and incorporated into the methodology of the main investigation to facilitate and consolidate the learning of new vocabulary by main investigation participants. Three techniques were identified as optimal learning techniques – pre-exposure technique, imagery techniques, in particular self-judgement tasks and errorless learning.

The pre-exposure technique involves presenting the stimuli to be learned to participants without requiring any response from them or involving any training of the item. Face association studies with individuals with memory impairment (see section 2.8.5.2) demonstrated that pre-exposure to novel stimuli significantly increased participants' ability to learn and recall the newly learned information (Kalla et al. 2001; Downes et al. 1997). Additionally, when this pre-exposure technique was combined with using imagery as a memory tool (where participants were asked to make judgements about the stimuli) it further significantly enhanced the number of items learned (see section 2.8.5.2). The success of this pre-exposure technique and participant judgement of the stimuli facilitated a staggered learning effect where the visual representation of the new stimuli was represented in the memory system before any further semantic or phonological knowledge was given (Kalla et al. 2001).

Another technique that has been proven to aid the learning and recall of new information is an 'errorless' learning approach. This paradigm asserts that people learn more successfully if they are prevented from making and reinforcing their own errors (Fillingham, Hodgson, Sage and Lambon Ralph, 2003) and therefore incorrect memory traces are not laid down. This approach was first used with animal learning studies where pigeons learned red-green visual discrimination using this method (Fillingham et al. 2003). The success of errorless learning was compared to errorful learning (where participants were encouraged to guess the correct answer/ procedure) in a number of studies and in all cases errorless learning was demonstrated to be more successful than errorful learning (Lorenzi and Taussik, 2000; Clare, Wilson, Breen and Hodges, 1999; Evans, Wilson, Schuri, Andrade, Baddeley, Bruna, Canavan, Della Sala, Green, Laaksonen, Baddeley and Wilson, 1994). This approach was used to successfully rehabilitate people with memory impairments in skills such as learning to perform word-processing skills (Hunkin, Squires, Aldrich and Parkin, 1998) and programming an electric organiser (Evans et al., 1998) where training incorporating 'errorless learning' led to a more effective acquisition of new skills. Robertson (1999) asserts that crucial to the efficient use of the brain's systems we should study in a fashion that minimises guessing and maximises trials where there is a strong chance of achieving the correct answer.

2.9.3 Method for recording and evaluating new learning

As discussion of previous learning studies demonstrates, there has been much variability in the methods used to evaluate the learning of new information (see section 2.8.6). There are many dimensions to knowing a word and many degrees of knowledge (Laufer and Nation, 1999); therefore in order to facilitate the demonstration of new vocabulary learning and to provide an appropriate method of recording participant performance a suitable model needed to be identified. The model had to enable the evaluation of language difficulties of participants to assess the severity of the aphasia; support the provision of a baseline measure of learning to enable a comparison between pre- and post-training knowledge; support the methodology for facilitation of learning the new vocabulary; facilitate the demonstration of this learning particularly for those who are unable to do so in spoken and/or written formats; enable measurement of any new learning by participants and finally, to enable predictions to be made about their abilities to learn new vocabulary in consideration of the various presentations of aphasia.

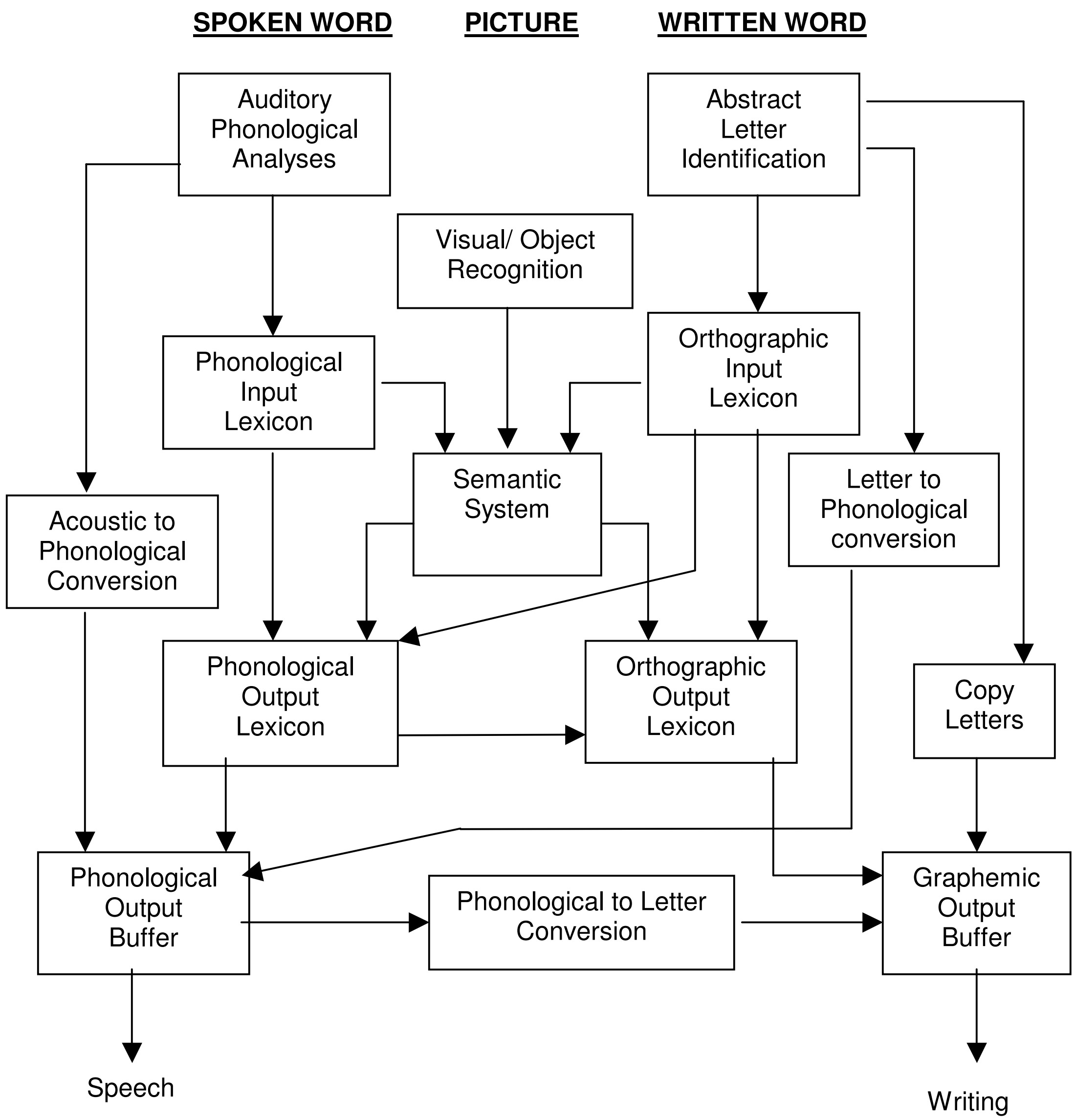


Figure 2i
Cognitive neuropsychology model of single word processing (Kay et al., 1992)

This requires quite a robust model and as the investigation is evaluating the learning of vocabulary a single word processing model based on the cognitive neuropsychological approach would be suitable (see section 2.7 and Figure 2i above).

One drawback of using this model is that it is off-line or static i.e. a snapshot of single word-processing ability at one moment in time, whereas learning is an on-line or dynamic process. While computer-based connectionist models may be more reflective of the dynamic process of learning, there is currently no behavioural model that will capture this learning process completely. The advantages of using the cognitive neuropsychological model however, is that firstly, it is a single word-processing model and the current investigation aims to facilitate the learning of single words. This model is commonly used by clinicians and researchers in identifying impairments of single word processing ability of people with aphasia using such assessments as the PALPA (Kay et al. 1992) (see section 2.7). Adaptation of these assessments to the stimuli of the current investigation will enable the assessment of each participant's ability to demonstrate learning of the new vocabulary. See Appendix 2.1 for an explanation of the function of each box in the cognitive neuropsychological model used in this investigation with an example of assessments that are thought to target the various modules and pathways which help establish which spoken and written language functions are impaired.

The use of this model will enable the investigator to capture not only participants' spoken and/or written output but also their recognition of the stimuli and any knowledge of the word forms or meanings that they may acquire. As the cognitive neuropsychological architecture of single word processing fulfils all requirements for facilitating the demonstration and evaluation of the learning of new vocabulary it will be used as a model for this investigation. The ability of the cognitive neuropsychological model to support the training and assessment methodology developed and used in the main investigation is presented in Chapter 4 (see section 4.7) and discussed in Chapter 6 (see section 6.5).

2.10 CHAPTER SUMMARY

Aphasia has been demonstrated to have a large and negative impact on the lives of the person with language impairment and their family and carers (see section 2.3). Evidence suggests that the recovery process can be slow and variable for each individual (see section 2.2.1). Although aphasia rehabilitation is generally considered to be efficacious, the outcome of the rehabilitation process for each person is uncertain. Some individuals recover most of their impaired language functions while others retain severe language impairment, affecting their communicative ability and essentially their participation in society (see section 2.4). There is abundant evidence that the healthy adult brain continually creates and recreates neuronal connections through each learning process it encounters. Such cortical plasticity has also been observed in the damaged adult brain where it has been demonstrated that individuals can relearn old motor and sensory skills through repeated exercises specific to the injured areas (see section 2.5.3). Higher cognitive functions have not yet been as thoroughly researched, particularly in the realm of language rehabilitation, although there is some evidence that cortical plasticity occurs in the recovery of language function. There is not yet a model or complete theoretical account of aphasia rehabilitation and it is not yet known if the process underlying language therapy involves the re-accessing or reactivation of already held memory traces or if in fact new learning is occurring despite speech and / or language difficulties. A small number of studies have evaluated the ability of people with aphasia to learn new associations between already held knowledge and new information (e.g. already known words with abstract symbols or familiar pictures with non-words) (see section 2.8.5.3). However it has not yet been established if people with aphasia can demonstrate the learning of new vocabulary incorporating both new word forms and new meanings.

This investigation aims to address this gap in our knowledge by facilitating the learning of new vocabulary and assessing the ability of people with aphasia to demonstrate this new learning. This information will contribute towards a theoretical account of aphasia rehabilitation. New words will be taught to people with aphasia using optimal learning techniques from learning approaches – pre-exposure, self-judgement and an errorless learning paradigm will be followed. The cognitive neuropsychological information-processing model of single word processing will be used to inform the design of the learning and assessment procedures (see section 2.9.3) and optimal techniques from theories of learning will be used (see section 2.9.2). The investigation will take both a top-down approach where active participation will be an integral part of the procedure ensuring to recruit attention gating (see section 2.6.3.3) and bottom up procedures will be utilised to facilitate repetition and rehearsal of learning with less errors invoked (see section 2.9.2) suggesting less maladaptive neuronal connections being made for the new vocabulary. The learning performance of each participant will also be evaluated in terms of the contributing factors that influence language recovery (see section 2.6) to hypothesise if predictions could be made about the ability of people with aphasia to learn affected by such influencing factors. As this is a pioneering study the stimuli and procedure will be developed and evaluated in preliminary studies in Chapter 3 and the piloting of the final methodology with healthy and post-stroke adults in Chapter 4. The main investigation will be presented in Chapter 5 where the results of each participant will be presented in the form of a case series. A discussion of the findings and its relevance to aphasia rehabilitation will be presented in Chapter 6.

Chapter 3 Preliminary Studies

3.1 INTRODUCTION

As discussed in Chapter 2, there have been a small number of investigations, which evaluated the learning of vocabulary by healthy adults with no history of brain damage, adults with memory impairment and adults with aphasia (see section 2.8.5 and subsections). These investigations mainly focused on the comparison of the effectiveness of various learning techniques in new learning. The investigations employed various stimuli to observe and assess vocabulary learning – foreign words, native language words considered to be unfamiliar to participants and non-words. However, these investigations essentially evaluated the ability of participants to pair or associate new information with already held representations rather than assessing the ability of participants to acquire new vocabulary representations (i.e. new word form and new meaning). As discussed (see section 2.7), there is currently no theoretical account or model of aphasia rehabilitation which makes the process(es) involved in the rehabilitation of aphasia explicit, and therefore it is not known if aphasia rehabilitation merely accesses already stored but currently inaccessible memory traces of language, or if new cortical connections are being made through new learning. A first step in addressing this area of knowledge is to establish if adults with aphasia can in fact demonstrate learning of new vocabulary despite residual language difficulties, which is what this investigation aimed to do. As this is a pioneering investigation there is currently no normative data from the adult population on the acquisition of this type of new vocabulary (number of items learned, strategies used etc.) or the appropriate type of stimuli to employ. Therefore preliminary studies were carried out with two main objectives. Firstly, the 'learnability' of the newly created stimuli (i.e. new word forms with novel meanings) were evaluated by adults with normal language and cognitive processes also providing normative data. Secondly, a number of methodological matters in preparation for the main investigation were addressed.

This chapter presents four preliminary studies that contributed to the development of the methodology for the main investigation. While previous investigations have examined the learning strategies of associating new stimuli with already known representations with healthy adults (see section 2.8.5.1) the strategies and their effectiveness used by this population in the acquisition of new vocabulary had not been examined. Preliminary study one addressed this matter by investigating what strategies or techniques were employed by healthy adults to learn this new vocabulary. Preliminary study two investigated if a particular learning strategy found to be used by high scoring participants in preliminary study one was related to the number of items that they could learn. As the stimuli had been created and paired by the researcher alone it was considered prudent to investigate any possible influences of this one-person design, therefore this study also investigated if there were intrinsic links between the various characteristics and attributes of the stimuli (rather than a particular learning strategy) that made them easier to learn. Additionally, it was determined whether some characteristics of the stimuli were easier to learn than others, for example, word form versus word meaning. This preliminary study also assessed the replication of participant performance from study one to evaluate reliability of performance. Preliminary study three investigated and reconciled conflict that arose from the previous two studies between the written novel word forms and their spoken pronunciations. Finally, preliminary study four ascertained if the various characteristics assigned to the images could be deduced from merely looking at the images and contributed to the development of a suitable method of presenting the stimuli for participants with aphasia in the main investigation. It also provided additional normative data on the learning of the stimuli by the normal population using a larger corpus of stimuli and participants. The stimuli were considered to be novel, however to eliminate any prior knowledge bias of the researcher and the possibility of triggering a familiar memory trace in participants it was considered prudent to confirm the uniqueness of the stimuli for the main investigation by the normal population. Preliminary studies one, two and four addressed this matter.

3.2 PRELIMINARY STUDY ONE

There were two main aims of this study, firstly, to examine how adults with normal language and cognitive functioning learn new vocabulary (both in terms of learning strategies and number of items learned) and secondly to evaluate the novel stimuli to ensure that they were appropriate for the training of new vocabulary. Five male (age range 28;01-53;09 years) and five female (age range 24;11-41;08 years) volunteer participants were recruited from the Speech and Language Sciences Department in Queen Margaret University College, Edinburgh. Participants were required to be under the age of 65 as this was to be the age range of the main investigation participants, considered young adults according to the National Health Service (NHS Scotland, 2000). All participants had normal cognitive and linguistic functioning. Participant employment status ranged from student, department secretary to lecturing and research staff.

3.2.1 Procedure

3.2.1.1 Stimuli

Ten new word forms matched with black and white line drawings of fantasy creature images were created by the researcher. Each creature was introduced to participants as an alien and was assigned an unusual skill (associative meaning) and one of five possible eye colours (Appendix 3.1). An audio pre-recording was compiled to accompany the stimuli as part of the training procedure that aimed to set a context for the new stimuli, give instructions for the tasks and present spoken representations of the novel word forms (Appendix 3.2).

3.2.1.2 Initial training and assessment procedure

It was anticipated that participants from the normal population would learn most (if not all) of the stimuli given sufficient time. It was envisaged that participants with aphasia in the main investigation would be under various pressures due to cognitive and language impairments, therefore it was decided to restrict the time allocated for learning for these normal participants and make observations about their learning ability under these pressurised conditions.

The pre-recorded audio script set a context for the introduction of the novel stimuli (Appendix 3.2) and participants confirmed that all character images were unfamiliar. They were then given the task of learning the name, skill and eye colour of each alien, on which they would be assessed at the end of the learning period. Participants initially viewed each stimulus for a period of 10 seconds alongside the pre-recorded information. This information was repeated with participants viewing the stimuli for a period of five seconds per stimulus. The researcher then left participants alone to learn the required details within a period of five minutes and using any learning techniques or methods that they wished.

3.2.1.3 Immediate recall

After five minutes elapsed the researcher returned and removed all stimuli and learning materials. Participants were assessed on their ability to recall everything that they could remember about each of the aliens (spoken recall). Following this the alien images were presented one by one and participants wrote the name and skill of each alien and coloured in the alien's correct eye colour from a selection of five colour pencils (written recall). There was no time limit on this task and no feedback was given upon its completion. All responses were audio recorded.

3.2.1.4 Delayed recall

Approximately two weeks following the training procedure participants were requested to participate for individual debriefings, the contents of which were not discussed beforehand. All participants attended. During this meeting participants were assessed on their ability to recall as much of the learned details as possible, firstly with no visual cue and then with the image of the creatures (spoken recall). Each participant then completed a multiple-choice task consisting of each alien's picture where they were required to choose one name from a choice of three (the target word and two non-word distracters), skill from a choice of three (the target skill and two other unusual skills) and also to colour in the aliens' eye colour (choice of five coloured pencils). This task made less demands on participants and aimed to ascertain if participants could demonstrate learning when provided with additional information even if they were unable to recall the names and skills spontaneously. All spoken responses were audio recorded. At least four days following the delayed recall session a further task was employed to ascertain if participants had in fact learned the names of the aliens or if the multiple-choice task simply reflected participant ability to recognise the trained items. Participants were required to match a picture of each alien with its correct name from a choice of three alien names from the training session.

3.2.1.5 Qualitative information

During the delayed recall session participants responded to a number of questions to inform the design of the main investigation. The questions investigated perceived pressures experienced by participants, the role of context in learning the information, clarity of instructions, the various modalities used to train, for example, auditory information, use of pre-recorded versus face-to-face interaction and the adequacy of the length of time given to complete the learning tasks. A summary of responses is presented in Appendix 3.3.

3.2.1.6 Scoring system

Correct recall of the aliens' eye colour was allocated a score of one or if 'incorrect' given zero. The correct recall of alien skills (associative word meanings) was also given a score of one. However, where the skill consisted of two or more words and only one of the target words was recalled they were allocated a score of 0.5 and no response or incorrect answer received zero. The scoring system for the acquisition of the novel words was more complex. A novel word was considered to be learned if the spoken and/ or written recall contained greater than 50% of the target phonemes / graphemes, plus, greater than 50% of these phonemes / graphemes in the correct order. This system aimed to reduce the number of responses with randomly assigned phonemes or letters being correct through chance alone.

By their nature multiple-choice assessment tasks contain an element of chance, which makes it difficult to evaluate if a participant's score represented this chance element or was a reflection of their ability to learn the stimuli. It was therefore decided that target items would be considered learned if participants demonstrated through other assessment tasks that they knew the items in question and also observation of participant indication of their knowledge of the target or if they were merely guessing.

3.2.2 Results

3.2.2.1 Immediate recall

Table 3.1 presents the total raw recall scores (spoken and written) for the name and skill of the aliens for both male and female participants. The scores identify a large range of performance indicating variability in the ability of healthy adults to learn new words (ranging from 0 to 9 new word forms and 2 -10 associative meanings learned each from a maximum potential of 10). When recalling the names and skills many of the participants listed them randomly, rather than linking the word forms and associative meanings together. It was felt that the written recall assessment task (participants wrote the name and skill next to the relevant image) was more indicative of the new learning of vocabulary. As the recall for eye colour appeared to behave differently from the skills and names, for example, most participants randomly chose colours stating that they were guessing, it was decided to exclude them from the results.

Table 3.1
Preliminary Study One
Total raw scores for immediate recall
(spoken and written names and skills)

Participant	Gender	Age	Spoken		Written	
			Name	**Skill**	**Name**	**Skill**
PS 1	Male	28;01	8	9	8	10
PS 2	Male	39;02	0	3	0	3.5
PS 3	Female	32;05	4	2	3	3
PS 4	Male	53;09	7	4	7	5.5
PS 5	Female	24;11	1	4.5	0	5
PS 6	Male	37;05	6	10	5	9
PS 7	Female	41;08	4	5.5	4	5
PS 8	Female	39;05	8	3	8	3
PS 9	Female	41;04	3	4	0	6
PS 10	Male	25;09	9	9.5	9	9.5

* PS1 = Preliminary subject 1 etc.

One-way ANOVA was conducted on both the number of word forms and number of associative meanings of the new words (i.e. skills) learned using gender as a factor with two levels (male and female) (SPSS for Windows, 2003). There was found to be a significant difference in terms of gender ability to recall the new associative meanings of the new words – $F(1, 10) = 9.963$, $p < .01$, but not for the ability to learn the new word forms – $F(1, 10) = 2.990$, $p = .101$. Therefore, both male and female participants had similar abilities to learn the new word forms and male participants recalled more associative meanings than female participants. One-way ANOVA was conducted on the number of items learned using type of item as a factor with two levels (new word forms and new skills)

(SPSS for Windows, 2003). A significant difference was found between the ability to learn the new word forms and the ability to learn the new skills, with more accurate responses for new word forms – F (1, 10) = 7.984, p=.011. One-way ANOVA was conducted on the number of items learned using type of recall as a factor with two levels (spoken and written recall) (SPSS for Windows, 2003). No significant difference was found between spoken and written recall performance – F (1, 10) = .002, p= .967.

3.2.2.2 Delayed recall

Table 3.2
Preliminary Study One
Total raw scores for delayed recall
(spoken , multiple-choice of names and skills and word-picture matching of names)

Participant	Gender	Age	Spoken		Multiple-choice		Word-Picture matching
			Name	Skill	Name	Skill	Name
PS 1	Male	28;01	1	5	10	10	8
PS 2	Male	39;02	0	0	9	10	9
PS 3	Female	32;05	0	1	9	9	10
PS 4	Male	53;09	1	0	9	8	5
PS 5	Female	24;11	0	2	9	10	10
PS 6	Male	37;05	0	3	8	10	3
PS 7	Female	41;08	0	0.5	7	9	10
PS 8	Female	39;05	1	1.5	10	10	10
PS 9	Female	41;04	0	0	9	10	3
PS 10	Male	25;09	2	2	10	10	9

* PS1 = Preliminary subject 1 etc.

Table 3.2 presents the total recall scores for both male and female participants for the delayed recall of new word forms and associative meanings. This data represents the retention of the new vocabulary learned from the training session. As with the immediate recall scores there was variability in participant ability to recall the newly learned vocabulary, ranging from 0 to 2 word forms and 0 to 5 associative meanings recalled each from a possible maximum of 10. This range indicates a large reduction of items remembered from the number recalled during the immediate recall assessment. The multiple-choice task demonstrated that participants had learned more information than they had demonstrated by spoken recall alone. The word-picture matching task indicated a deeper level of learning where participants were able to match the names of the aliens with the appropriate images rather than merely recognising the stimuli in the multiple-choice task. Two examples of participants demonstrating these different levels of learning are PS2 who could choose 9 names correctly from the multiple-choice task and also matched these to their correct image, indicating that in addition to recognising the stimuli he had learned it at a deeper level, retaining more semantic information. Whereas PS9 selected 9 names correctly from the multiple-choice task but could only match 3 items correctly to the target images, suggesting that she recognised the stimuli but the depth of learning had not developed to enable her to match the names and images.

3.2.3 Learning strategies used by participants

Table 3.3 below presents some examples of methods that participants reported using to learn the new vocabulary.

Table 3.3
Preliminary Study One
Examples of learning strategies used as reported by participants

High scoring participants		
Strategy	**Creature**	**Quotes from participants**
Descriptive	Hamekin Curvol	Like a bunch of flowers; like clouds & they are calm looking. Shaped like a psychology sign & psychic skill is linked to psychology
Using familiar rhyming words	Hamekin	Sounds like Ramekin
Making initial letters into mnemonic phrase	All	Fay's Vest Smells Zesty etc. (futarg, vintrok, snaitle, zoodop)
Linking name to image	Lundril	Looked like a park with lots of trees – a London park
Low scoring participants		
Strategy	**Creature**	**Quotes from participants**
Written copying	All	Wrote down list of creature names and skills
Drawing	All	Drew creatures beside above lists
Spoken repetition	All	Kept repeating names and skills aloud

Those participants who scored the highest used learning strategies including descriptive analogies, linking words to rhyming words, making mnemonic phrases and also linking the name of the creatures to particular mental images. The other participants' learning strategies included writing names, skills and in some cases drawing images of creatures, spoken repetition of details and some participants stated that they did not have a learning strategy.

Participants were grouped into the high scoring group (Group A – PS1, 4, 6, 7 and 10) versus the low scoring group (Group B – PS2, 3, 5 and 9) to ascertain if there was a significant difference between the high scoring participants, who used mnemonic techniques, and the low scoring ones who did not. As PS8 was unable to participate in the second preliminary study she was excluded from these calculations. One-way ANOVA was conducted on the number items learned using learning strategy as a factor with three levels (word forms, word meanings and type of learning technique) (SPSS for Windows, 2003). A significant difference was found between the type of learning strategy used for both word forms – $F(2, 9) = 8.288$, $p<.01$ and word meanings – $F(2, 9) = 20.621$, $p<.01$. Therefore those participants who reported using mnemonic learning strategies achieved greater learning performance for both word forms and word meanings than those who did not use this type of learning strategy. As mnemonic learning strategies appeared to enhance the number of items learned it was possible that main investigation participants with aphasia could use it to enhance their learning of the new vocabulary.

3.2.4 Discussion and implications

The aims of preliminary study one (see section 3.2) were achieved. As evident from the results there was large variation in the performance of participants for both the immediate recall (see Table 3.1) and the delayed recall assessments (see Table 3.2). Participants were not advised that there would be a delayed recall assessment session therefore it was unlikely that there was conscious rehearsal taking place prior to the assessment. However, despite no additional rehearsal or consolidation of learning, as well as the training being short and intensive, some of the novel representations were stored in long-term memory and recalled when required (see Table 3.2). The qualitative data recorded that those participants who achieved the higher scores reported that they used mnemonic type strategies as depicted in Table 3.3. Those with the lower scores reported that they employed learning methods such as written copying of details; learning by repetition and others were unable to explain their learning strategy. The stimuli used in this first preliminary study proved to be suitable for training new vocabulary in adults of normal language and cognitive functioning (see Table 3.1).

The data from preliminary study one (see section 3.2.3) raised a number of questions that were addressed in preliminary study two (see section 3.3). Firstly, could the lower scoring participants from Group B (PS2, 3, 5 and 9) enhance their learning scores for similar new vocabulary through training in mnemonic learning strategies immediately prior to a training session? If so, it would suggest that it might be useful to teach such strategies to participants with aphasia in the main investigation prior to training, in order to enhance their learning of the novel stimuli. Secondly, as the images, skills and novel names were created and linked by the same person, was it possible that the mnemonic learning techniques, used by Group A (PS1, 4, 6, 7 and 10), were successful due to the influence of some intrinsic link between the stimuli? Or would these techniques be similarly successful if the names, eye colour and skills were randomly assigned to each image? Additionally, preliminary study two anticipated observing the replication of learning performance by participants thus demonstrating reliability of results from preliminary study one.

3.3 PRELIMINARY STUDY TWO

This study addressed the questions raised from the findings in preliminary study one as discussed in 3.2.4. Firstly, the possibility of the use of particular learning strategies to enhance the learning of all participants which could identify optimal learning techniques for the main investigation participants. Secondly, to evaluate characteristics of the stimuli to be learnt and thirdly, to demonstrate the reliability of preliminary study one results.

3.3.1 Procedure

Nine participants from study one participated in this study. One of the female participants was unable to be involved due to a change of location. The participants were divided into Group A (those with the high five scores) and Group B (those with the low four scores).

3.3.1.1 Stimuli

An additional ten new word forms were created by the researcher and matched with black and white line drawings of another ten unusual creature type images. Each alien was assigned a special skill and one of five possible eye colours. Although study one considered that eye colour was learned differently than the names or skills of the aliens they were included for replication purposes. The stimuli for participants in Group B used the stimuli as originally designed by the researcher (see Appendix 3.4a). However, the stimuli for Group A were randomly assigned their name, skill and eye colour (Appendix 3.4b) to ascertain if there were intrinsic links between the alien characters and their word forms and / or skills that facilitated their high score in any way.

3.3.1.2 Initial training and assessment procedure

The training and assessment procedure was a replication of preliminary study one (see section 3.2.1) with two additional features. Firstly, immediately prior to training, the successful learning techniques from the high scoring group in study one were discussed with each participant with examples of each learning approach. Participants were requested to use these mnemonic techniques when learning the new stimuli. Additionally, a multiple-choice task was introduced in the immediate recall of the learned information to allow comparison between immediate and delayed recall of the items learned (see section 3.2.1.4).

3.3.2 Results

3.3.2.1 Immediate recall

Table 3.4 below presents the raw score results from the immediate recall assessment from this preliminary study.

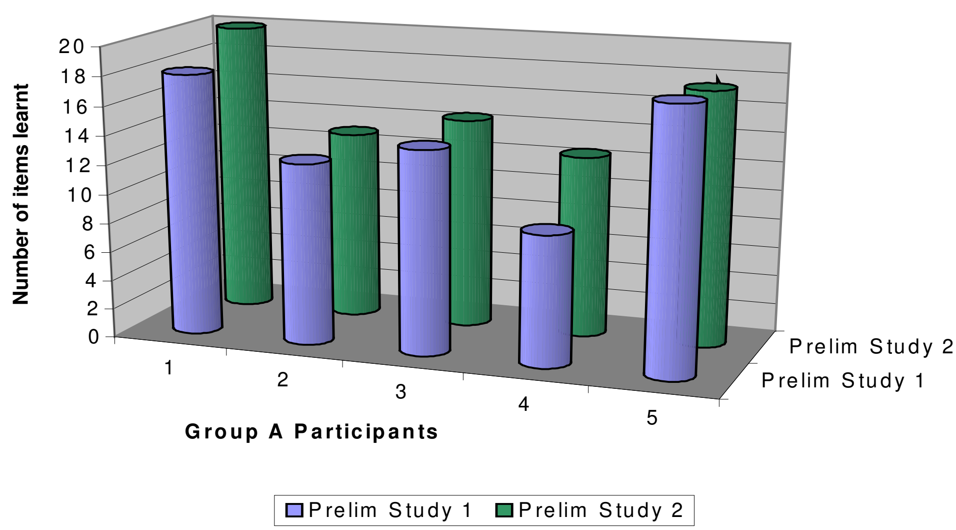
Table 3.4
Preliminary Study Two
Total raw scores for immediate recall
(spoken and written names and skills)

Participant	Gender	Age	Spoken		Written		Multiple-choice	
			Name	Skill	Name	Skill	Name	Skill
GROUP A participants								
PS 1	Male	28;01	8	8	10	10	10	10
PS 4	Male	53;09	5	4	7	6	10	10
PS 6	Male	37;05	8	7	6.5	8	9	10
PS 7	Female	41;08	3	6	5	7.5	10	10
PS 10	Male	25;09	9	6.5	9	8.5	10	10
GROUP B participants								
PS 2	Male	39;02	4	3	7	9	10	10
PS 3	Female	32;05	5	4.5	4	3.5	10	9
PS 5	Female	24;11	5	4	7	9	9	10
PS 9	Female	41;04	2	2.5	3	3	9	9

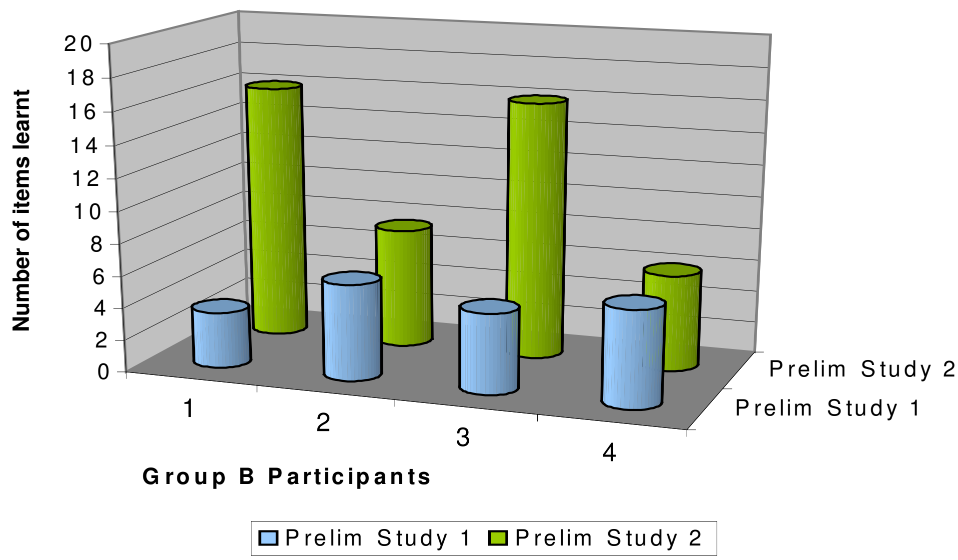
* PS 1 = Preliminary subject 1 etc.

As with preliminary study one, there was a wide range of performance scores varying from 2 to 8 word forms (spoken recall) and 3 to 10 word forms (written recall) and 2.5 to 8 skills (spoken recall) and 3 to 10 (written recall) each with a maximum potential total of 10 items. The performance of each group in preliminary study two was compared to that in preliminary study one – Group A and Group B (Graph 3.1 and 3.2 below). One-way ANOVA was conducted on the number of items learned by Group A using reliability between preliminary studies as a factor with two levels (preliminary study one and preliminary study two) (SPSS for Windows, 2003). No significant difference was found in the ability of participants in Group A to learn this new set of stimuli compared to that of preliminary study one – $F(1, 9) = 2.726$, $p = .118$. This indicates both reliability of performance for Group A between the two preliminary studies and no evidence of any intrinsic link between the new word forms and their meanings which could have influenced learning ability.

Graph 3.1
Comparison of number of items learned by participants in Group A from immediate recall (written) preliminary studies one and two



Graph 3.2
Comparison of number of items learned by participants in Group B from immediate recall (written) preliminary studies one and two



While some participants in Group B improved their performance using mnemonic techniques this was not significantly different for the group as a whole, suggesting that mnemonic type learning is suitable for some but not all learners of new vocabulary. Qualitative data identified interference from the items learned in preliminary study one for a number of participants, from both the new word forms (for example, 'wangor', 'futarg', 'yamtork', 'curvol' and 'zoodop') and associative meanings (for example, 'creates calm' - four participants and 'hypnotises'). This suggests that the new vocabulary details were still retained from preliminary study one and were activated when other semantically related (i.e. new aliens) representations were introduced.

3.3.2.2 Delayed recall

After a minimum of six weeks following training all nine participants partook in the assessment of the retention of the newly learned vocabulary.

Table 3.5
Preliminary Study Two
Total raw scores for delayed recall
(spoken and written names and skills)

Participant	Gender	Age	Spoken		Written		Multiple-choice	
			Name	Skill	Name	Skill	Name	Skill
GROUP A participants								
GA1	Male	28;01	0	0	1	1	10	8
GA2	Female	24;11	0	0	1	1	10	10
GA3	Male	37;05	0	0	0	1	9	5
GA4	Female	41;08	0	0.5	0	0	10	9
GA5	Male	25;09	0	0	0	0.5	9	9
GROUP B participants								
GB1	Male	39;02	0	0	1	0	10	9
GB2	Female	32;05	0	0	0	0.5	9	7
GB3	Male	53;09	0	0	0	0	8	7
GB4	Female	41;04	0	0	0.5	1	9	8

* GA1 = Group A participant 1 etc.

The same assessment procedure was followed as that in the immediate recall (see section 3.3.2.1) and the results are presented in Table 3.5 above. Unlike the immediate recall none of the participants from either Group A or Group B were able to recall any of the names or skills for spoken recall (with the exception of GA4 who recalled part of one skill). The written recall also reflected this difficulty in recalling the new vocabulary with the range of scores varying from 0 to 1 for both names and skills. However, all participants were better able to complete the multiple-choice assessment and the range of scores varied between 8 and 10 for name and 5 to 10 for skills. As with preliminary study one delayed recall (see section 3.2.2.2) the multiple-choice task indicated that participants had learned more information than they had demonstrated by spoken recall alone.

As with preliminary study one, participants responded to a number of questions to inform the design of the main investigation. The questions investigated if they felt that the learning strategies discussion prior to training contributed to their ability to learn the new vocabulary. Participants were also asked what they thought had hindered their learning in any way, including time scale given to learn the new vocabulary. A summary of their responses to these questions is in presented in Appendix 3.5.

As the spoken recall task was the only replicated assessment in the delayed recall of preliminary studies one (see Table 3.2) and two (see Table 3.5) it was used to compare the number of items remembered for each study. This comparison suggested that despite participants possibly predicting that they would be asked to perform these delayed recall tasks again (from their experience in preliminary study one), they were unable to retain this information in their long-term memory for longer than six weeks. Another interesting observation, which was similar to immediate recall, was the apparent interference from the new vocabulary previously learned in preliminary study one for a number of participants for both word forms (futarg - two participants, curvol, wangor and yamtork - two participants) and associative meanings (creates calm - four participants).

3.3.3 Discussion and implications

The aims of preliminary study two (see section 3.3) were achieved. The first aim examined the potential use of particular learning strategies (i.e. mnemonic techniques) that were used by high scoring participants in preliminary study one (Group A), with a view to enhancing the learning performance of those participants who achieved low scores (Group B) in preliminary study one. It was thought that if mnemonic techniques proved successful they could then be incorporated into the methodology of the main investigation. The results (see section 3.3.2) indicated that the use of mnemonic techniques improved learning performance for some but not all participants. Therefore, as different learning strategies appeared to be useful for different participants it was decided to introduce a variety of learning strategies to main investigation participants and encourage them to use the one most suited to their particular learning style.

As the novel word forms, images and associated meanings (i.e. skills) were created and linked by the same person, the second aim of this preliminary study involved an evaluation of the characteristics of the stimuli to be learned. It aimed to assess if there were any intrinsic links between the various components of the stimuli that facilitated the learning of those participants who used the mnemonic technique above those who did not. To this end the novel images to be learned by Group A were randomly assigned their various attributes (i.e. name, skill and eye colour). The results (see Table 3.4) indicated that the high scoring participants from preliminary study one (Group A) were also the high scorers in preliminary study two. These results have two indications. Firstly, high scores were achieved despite the randomisation of the stimuli attributes and therefore there did not appear to be any intrinsic links between the novel stimuli that would influence learning performance. Secondly, the persistent high performance of Group A participants successfully achieved the third aim of this preliminary study in that they demonstrated the reliability of preliminary study one results by replicating their stronger learning performance.

Preliminary study two again demonstrated a wide range of learning ability by the normal population, further supporting the suggestion that a matched control was not required for the main investigation. No practice effects between preliminary studies one and two were apparent and some people actually performed worse in the second study, although not significantly.

During the assessment phase of preliminary study two it was noted that although all participants heard the new word forms on a number of occasions during the training session, some participants altered the pronunciation and syllable stress of two words from those presented. As some people with aphasia have auditory comprehension difficulties and may support their learning using the written representations of the new words, it was decided to investigate whether there was a conflict between the written and spoken representations of the novel words. This was addressed in preliminary study three.

3.4 PRELIMINARY STUDY THREE

As discussed above the aim of this study was simply to investigate and reconcile any conflict between two of the written novel words used in preliminary studies one and two and their spoken pronunciations (namely, HAMEKIN and JUNFLIZ).

3.4.1 Procedure

Ten participants (four male and six female) were chosen randomly from the researcher's acquaintances and friends, with the proviso that they had not taken part in preliminary studies one and two and were not aware of the aims or details of this preliminary study or the main investigation. The twenty novel words from preliminary studies one and two were typewritten as a list on an A4 page. Participants were required to read aloud the 20 novel words, as they would expect them to be pronounced. These pronunciations were transcribed using broad phonetic transcription.

3.4.2 Results

The two words from preliminary studies one and two that, for some participants, were in conflict with the original trained pronunciation were the main focus of the findings (namely, HAMEKIN and JUNFLIZ). Seven of the ten participants read the word 'HAMEKIN' with three syllables i.e. [haməkən] rather than the two originally intended syllables i.e. [heɪmkən]. Nine participants pronounced the initial vowel [ʌ] from the word 'JUNFLIZ' i.e. [dʒʌnflɪʦ] as was intended, so this remained unchanged. The final consonant of 'JUNFLIZ' also caused difficulties in the first two studies with many participants pronouncing it [dʒʌnflɪz]. Nine participants in this study also pronounced the ending as [z] and therefore this pronunciation was changed for the main investigation. It was noted that another new word was read aloud differently than originally created (TRAIGOL) i.e. [tɹaɪgɔl], All ten participants pronounced it as [tɹeɪgɔl] instead of the intended pronunciation.

3.4.3 Discussion and implications

The transcriptions from the ten participants demonstrated that the majority of the written words matched their expected spoken pronunciations with the exception of the words HAMEKIN and JUNFLIZ. These were amended for the main investigation. Unexpectedly, one other creature was pronounced differently than anticipated (i.e. TRAIGOL), however as there had been no difficulties with its pronunciation by any participants in the previous two preliminary studies it was not deemed necessary to change this item for the main investigation - either pronunciation would be acceptable by future participants.

As discussed (see section 3.3.3) it was decided not to train a matched participant control group with the stimuli as part of the main investigation due to the evident variability in learning by the normal population. It was however considered useful to evaluate the amount of time required by this population to learn the additional stimuli and also to obtain additional normative data on new learning as the sample population was small. A further preliminary study was planned to further this end.

3.5 PRELIMINARY STUDY FOUR

This study had a number of aims. Firstly, to ascertain if the word forms (names) or associated meanings (skills) of the 20 novel images could be deduced from merely looking at the images alone. It also aimed to provide more data on the learning of new word forms with new word meanings by the normal population using a larger corpus of stimuli and participants. This study would also inform the timing and number of stimuli to be learned by participants in the main investigation.

3.5.1 Procedure

Two groups of 3rd year speech and language therapy students from Queen Margaret University College, Edinburgh participated in this study. Participants included 63 females and two males with an age range between 19 and 46 years. Sixty-two of these participants were native English speakers.

3.5.1.1 Initial training and assessment procedure

All twenty word forms and paired associated meanings from preliminary studies one and two were presented for learning. The alien images were presented by overhead projection one by one and participants were required to guess the alien names as well as possible skills they would imagine them to possess (responses in written form). A brief discussion describing various strategies found to enhance the learning of new information followed this task and data from preliminary studies one and two were employed to offer examples of possible learning methods (see Table 3.3). Participants were then trained in the names and skills of each creature. Each alien was presented again along with its name and skill (both in spoken and written form). Participants were then given a copy of the stimuli to learn the name and skill of each alien in any manner that they wished for a period of 10 minutes. They were advised not to consult with their peers at this stage. After 10 minutes elapsed participants were advised to work with their peers to consolidate their learning for a further period of 15 minutes. The option of doing so over coffee was accepted by all participants. All materials were gathered from the students after this training period and participants were asked not to communicate with their peers during the assessment tasks. The images were presented one by one in the same order as the initial presentation and participants were required to write down the name and skill of each alien. Participants' written responses were collected. They were then given a multiple-choice task in which they had to choose the aliens' names and skills from an option of three. Their responses were then collected.

3.5.2 Results

None of the 65 participants could guess the name or skill of any of the 20 aliens prior to the learning phase. This confirmed that although participants for preliminary studies one and two reported that some of the images tended to aid their learning, the actual images did not facilitate name or skill deduction. Table 3.6 below presents a selection of the names and skills that some of the participants suggested for the aliens. As none of the suggested names or skills were similar to the original stimuli all 20 names and 20 skills were included in the main investigation training procedure as new vocabulary.

Table 3.6
Preliminary Study Four
Some participant suggestions as to the names and skills of the stimuli

Alien name	Suggested names	Alien skill	Suggested Skills
futarg	bobo, james, spike, fred,	**freezes enemies**	scaring, poison tongue
pentar	chickpea, flashy	**Invisible cloak**	wings of fire; flapping,
vintrok	travis, pumpkin head	**spins nets**	wobbles, being evil
curvol	queen cactus, bernie brush	**psychic**	flying to texas, brushing

Table 3.7 below presents the performance scores of all 65 participants and highlights again the variability of learning abilities within the normal population.

Fifty four percent of participants recalled 50% or more of the alien names whereas all 65 (100%) participants demonstrated this learning when given additional information using the multiple-choice task. The skills were easier to recall, with 89% of participants recalling 75% or more skills compared to 31% of names recalled.

Table 3.7
Preliminary Study Four
Performance of participants on assessment tasks

Number of correct items	Recall names (%)	Recall skills (%)	Multiple-choice names (%)	Multiple-choice skills (%)
15-20	20 (31)	58 (89)	60 (92)	65 (100)
10-14	15 (23)	6 (9)	5 (8)	0 (0)
5-9	18 (28)	0 (0)	0 (0)	0 (0)
0-4	12 (18)	1 (2)	0 (0)	0 (0)

As discussed (see section 3.2.2.2) the multiple-choice task requires a reduced level of learning (recognition of the stimuli) than cold recall tasks. However, all participants scored well above chance (92% identifying between 15 and 20 names and 8% identifying between 10-14 names) and all participants identified between 15 and 20 skills. As Table 3.7 indicates these recognition scores were well above the initial recall scores therefore the multiple-choice task proved a more effective facilitator of memory recall (albeit a demonstration of a less depth of learning) than cold recall tasks.

3.5.3 Discussion

Although this was not a controlled study (i.e. participants sat side-by-side within a classroom setting), it demonstrated that none of the alien names and skills could be guessed from their images alone. The study also provided further data on learning a larger number of stimuli with a greater number of participants. Additionally, a combination of independent learning and controlled learning was introduced during this study allowing students to choose their preferred learning strategies. In contrast to preliminary studies one and two, the names of the aliens were more difficult to recall and the skills relatively easier. This could not be a reflection on the 'newness' of the word forms as they were the same ones that were used in the previous two preliminary studies. However, there were a number of differences between this study and the other two, namely, the number of stimuli was increased in number from ten names and ten skills to 20 of each; independent learning time was increased with an option of working with their peers which may have provided additional distractions when learning. As with preliminary studies one and two there was a wide range of learning ability to recall the vocabulary. Participants were able to demonstrate a greater amount of learning when given more cues to aid recall as reflected in the multiple-choice task scores (see Table 3.7).

3.6 CONTRIBUTION OF PRELIMINARY STUDIES' FINDINGS TO MAIN INVESTIGATION

As the main investigation (Chapter 5) aimed to ascertain if people with aphasia could learn new word forms and meanings, it was imperative that the methodology of the study facilitated the maximum demonstration of any learning. These preliminary studies aimed to discover the optimum training method to facilitate this learning and assist in the demonstration of this learning through appropriate assessments. The contribution of the preliminary studies to the main investigation method will now be discussed.

3.6.1 Stimuli properties

3.6.1.1 Uniqueness of stimuli

The stimuli (images, word forms and novel associative skills) were original designs of the researcher and considered novel. In order to ensure that the learning and recall of the stimuli was not contaminated by information already known to the researcher a number of steps were taken. Firstly, prior to the preliminary studies the British National Corpus (1998) confirmed that all 20 word forms used in the studies were unique with each scoring zero on the word familiarity search. Secondly, all participants from preliminary studies one, two and four confirmed that the stimuli were not familiar to them.

3.6.1.2 Number and type of items to be learned

The preliminary studies provided evidence that there was a wide range of learning abilities in normal participants and that a number of these participants could learn all names and skills. It was uncertain however, whether the main investigation participants would be able to demonstrate any learning of the new vocabulary. Consideration of the number of items that adults with aphasia could learn raised the possibility of reducing the amount of information to be learned to the names alone. However there were concerns that participants would learn the word forms as proper nouns (see section 2.8.3). Additionally, learning theory advocates that new words are best learned by forming associations with already held concepts or words, consolidating the meaning to already held information (Levelt et al., 1999). Therefore it was decided to develop the new words in relation to a ‘semantic links’ model. Each alien was now considered to be a ‘creature’ (more familiar and perhaps more ecologically valid than aliens) and would have a name (novel word form), an image (novel meaning), a special skill (associative meaning using ‘real’ words with unusual semantic concepts) and a habitat and food source (‘real’ words with new associative links). Five creatures would be semantically linked by the categories of habitat and food source. The stimuli used for the main investigation are presented in Appendix 3.6. As discussed (see section 3.2.2) the learning of eye colour appeared to perform differently than the other stimuli in preliminary study one and so they were not included in the main investigation.

3.6.2 Control issues

Preliminary studies one, two and four presented the wide spectrum of performance by the normal population in their ability to learn and recall novel information and indicated that a matched control population was not required for the main investigation. The stimuli were proven to be novel and there was confidence that participants had no memory trace of the stimuli, therefore untrained control stimuli was not required.

3.6.3 Training procedure

Qualitative data encompassing the comments of participants from preliminary studies one (see Appendix 3.3) and two (see Appendix 3.5) indicated that the scenario of the earth being invaded was unnecessary and distracting for some participants. The scenario was therefore eliminated from the main investigation training procedure.

While a larger number of participants stated that they would prefer to listen to details of the stimuli by tape recording during the training period, others preferred the information to be given face-to-face. Further, some participants responded positively to the recording and given more time would have liked the opportunity to replay the details to aid their learning. To cater for all preferences it was decided that the stimuli would be given in spoken form face-to-face and the opportunity would also be given to listen to an audio recording of the details during the participants' 'independent learning time' (ILT) if they so chose.

While the performance of the high score participants in preliminary study one suggested that mnemonic strategies were successful, preliminary study two demonstrated that these strategies were not suited to everyone's learning style. It was therefore decided for the main investigation to introduce a short discussion with participants prior to the training session. This involved the description of various learning strategies used by preliminary study participants where main investigation participants were encouraged to choose their own preferred method of learning.

3.6.4 Assessment procedure

The preliminary studies also informed the assessment methodology of the main investigation. Although type of recall (i.e. spoken versus written) was not significant in the preliminary studies (see section 3.2.2), participants stated that spoken recall without any visual cues (for example the pictures of the creatures) was their most difficult assessment. Therefore in order to facilitate the demonstration of learning by main investigation participations, a picture of each creature would be presented during the spoken and written recall to aid retrieval. The multiple-choice assessment tasks were shown to facilitate better memory recall as a learning and recognition task than cold recall tasks, therefore the assessment procedure of the main investigation would include a recognition task in order to capture this level of learning.

3.7 CHAPTER SUMMARY

The aims of the four preliminary studies were achieved. Normative data for the learning performance of 75 adults with normal language and cognitive skills was acquired which demonstrated the wide range of ability of the normal population to learn new vocabulary. The types of learning strategies which were used by participants in preliminary study one were examined and the one that appeared to be most successful (mnemonic type strategies) was found to be of assistance to some but not all of the population (preliminary study two). Highlighting the various types of learning strategies to those participants in the learning study prior to the training period was considered a useful tool for the main investigation.

The novel stimuli were evaluated and considered to be suitable to use as new vocabulary both in word form and word meaning and were considered 'learnable' by the healthy adult population (preliminary studies one, two and four). The results of preliminary study three resolved the conflict between the written novel words and their spoken pronunciation, which arose for two of the word forms 'hamekin' and 'junfliz' and their pronunciation for the main investigation were amended accordingly. Participants in preliminary study one replicated their learning performance in preliminary study two. No practise effect was observed between preliminary studies one and two (although interference was observed between the studies) – some participants improved their learning performance, others remained the same and other participants performed slightly worse. There was no overall significant difference between the two studies.

Being unique, participants would have no memory trace of the stimuli and therefore there was no requirement for 'untrained' stimuli for control purposes. Preliminary studies one, two and four strongly demonstrated a wide variation in the number of stimuli learned by the adult 'normal' population indicating that a matched control population would not be appropriate for the main investigation. The variability of learning preference (tape recording versus face-to-face) and assessment preference (with and without visual cues) informed the main investigation to include a variety of procedures to assist in the facilitation of learning and retrieving the new vocabulary by participants in the main investigation. In addition, as participants reported that they felt more comfortable memorising the new vocabulary alone, a period of 'independent learning time' during the main investigation would be combined with face-to-face interaction with participants.

Further, it was envisaged that various influencing factors resulting from participants' stroke could affect their ability to learn the new vocabulary and perhaps reduce the number of items they could potentially learn (see section 2.6). Previous studies have not indicated the optimum amount of information that people with aphasia could learn (see section 2.9.1). It was decided therefore, to propose a training regime of five creatures per day for a period of four days and offer a period of independent learning time of 30 minutes each day following the initial training. This proposed methodology was evaluated in the next three studies (Chapter 4), which involved the piloting of the procedure with an adult with normal cognitive and language processing, an adult who had a stroke but did not have aphasia as well as with an adult with aphasia.

Chapter 4 Pilot studies: finalisation of methodology for the main investigation

4.1 INTRODUCTION

The preliminary studies (Chapter 3) shaped the design of the stimuli and the methodology for the training and assessment of new vocabulary learning for the main investigation. Normative data for the learning of the new stimuli was acquired from 75 adults with no history of brain damage, cognitive or language difficulties. As it was established that the 20 novel words were original by all participants there was no requirement for untrained stimuli for control purposes in the main investigation. The preliminary studies also indicated that there was no requirement for a control group due to the wide range of learning abilities by the normal population. Additionally, the main investigation addresses the question of whether adults with aphasia are able to demonstrate the learning of new vocabulary, which is unknown to date, rather than comparing their capacity to learn with the normal population. Optimal learning strategies used by preliminary study participants were investigated in preliminary studies one and two. As no one strategy was found to be effective for all participants it was decided that a number of learning strategies would be shown to the participants with aphasia in the main investigation, who would then choose their own preferred learning strategy.

This chapter describes the final development of the methodology for the main investigation. The completed methodology aimed firstly to facilitate the learning of the novel word forms and their meanings during the training period and secondly, to structure the assessment of this new learning to enable participants with aphasia to demonstrate any information that they may learn. The procedure (see section 4.2 and 4.3) was therefore compiled incorporating theories of learning, the cognitive neuropsychological approach and the findings of the preliminary studies as described in Chapter 3. The procedure was then evaluated with an adult with no history of stroke and who was considered to have normal cognitive and linguistic abilities (pilot study one, see section 4.4), an adult who had had a stroke but was not aphasic (pilot study two, see section 4.5) and finally with a post-stroke adult who presented with aphasia (pilot study three, see section 4.6).

4.2 SCREENING ASSESSMENT PROCEDURE

Screening assessments (discussed below) were administered prior to the training sessions to establish the cognitive and linguistic abilities of each participant, as well as to establish their overall emotional state at the time of the investigation. In order to highlight various methods of learning new information, while allowing participants to choose their own preferred method (see section 3.3.3), common methods of learning were discussed during this initial session and a leaflet depicting each method (in written and picture format) was given to each participant (see Appendix 4.1).

4.2.1 Evaluation of emotional well-being

As a person's emotional state (such as depression and anxiety), may influence their motivation to learn (see section 2.3.1 and 2.6.3.2), the Hospital Anxiety and Depression scale (HADs) (Zigmond and Snaith, 1983) was completed with each participant (see Appendix 4.2). This is a self-evaluation questionnaire that has been established as a self-rating instrument for depression and anxiety. While significant aspects of the syndromes of anxiety and depression are not covered by this scale, a study involving a population of 65,648 participants found that the HADs was an instrument that had good psychometric properties (Mykletun, Stordal and Dahl, 2001). The scoring system for the HADs was followed according to instructions and results indicated whether an individual's emotional status was ‘normal’ (0-7), ‘borderline abnormal’ (8-10) or ‘abnormal’ (11-21) (see Appendix 4.2).

4.2.2 Screening of cognitive abilities

The cognitive abilities of each participant were screened and their ability to learn a non-verbal or non-linguistic task was assessed. The assessments used are discussed below.

4.2.2.1 The Cognitive Linguistic Quick Test (CLQT)

The CLQT (Helm-Estabrooks, 2001) is a published standardised screening assessment that employs 10 tasks to provide information on the relative integrity of attention, memory, executive functions, language and visuospatial skills. Clock drawing skills are also assessed and can be used as a mini-screening task for cognitive impairment in itself (Helm-Estabrooks, 2001). Severity ratings are given for each task and each cognitive domain. The CLQT was employed in this investigation to assess a range of cognitive strengths and weaknesses among participants across the five cognitive domains. The scoring system of the CLQT sub-tests was followed according to the instructions. Published normative data and task descriptions for the CLQT are presented in Appendix 4.3.

4.2.2.2 Non-linguistic learning task

To demonstrate that each participant had the cognitive capacity to learn, a non-linguistic task was devised. This was based on a learning task evaluated by Evans et al. (2000). This ‘stepping-stone route’ task involved the creation of a 6 x 6 abstract patterned ‘stepping stones’ paper-based template (see Appendix 4.4). The task was to commence the route at the arrow at the bottom of the template and travel up toward the square highlighted on the top line using only nine moves. As the study followed an errorless learning approach (see section 2.9.2) any route that was not permitted was ‘blocked off’ by a single line. There was only one possible successful route. Participants were instructed to find and remember the route taking them from the bottom arrow to the top arrow while avoiding the prohibited black lines. They rehearsed this task five times in succession. Participants were given a fresh copy of the ‘stepping-stone’ route with the prohibited routes removed. Each participant was then required to complete the route that they had learned. After a break of three minutes (filled with general conversation) participants performed this task once more as a delayed recall task. They had not been advised that they would be required to complete a delayed recall assessment. Each correct move was scored one point and all incorrect moves were allocated zero. There were a possible maximum of nine accurate moves for each completed route. The immediate recall and delayed recall scores were combined to produce a total possible score of 18.

4.2.3 Screening of language abilities

A language screening test using single words was compiled by the researcher and administered to each participant (see Appendix 4.5). The items included extracts from published assessments such as the PALPA (Kay et al, 1992) and picture stimuli from the literature (Snodgrass and Vanderwart, 1980). The assessment included:

- Repetition of eight words and eight non-words (PALPA, Kay et al, 1992).
- Auditory lexical decision of the above 16 words. This involved participants hearing words and non-words and indicating if they were real words or non-words.
- Naming of 12 items from Snodgrass and Vanderwart (1980). These items were selected on the basis that they had high naming agreement (98-100%) and high image agreement (greater than 4). Six of these words had high familiarity rating and six words had low familiarity rating.
- Reading of eight words and eight non-words (same words as used in repetition task above).

- Visual lexical decision of these 16 words. This involved participants reading words and non-words and indicating if they were real words or non-words.
- Categorisation tasks involving (a) 15 shapes (five circles, five squares and five triangles), (b) 15 colour pictures (Boardmaker Picture Index, 1996), five each of two closely related semantic categories (fruit and vegetables), and five from an unrelated semantic category (clothes) and (c) the typed labels of the 15 pictures from (b) above.
- Written spelling of six words and six non-words to dictation (PALPA, Kay et al, 1992).

4.2.3.1 Scoring system for language abilities

All accurate responses were allocated one point. All reading, repetition, categorisation and spelling tasks were required to be 100% accurate to receive this score, otherwise they scored zero. The naming task had a different scoring system. Where a participant could name the stimuli but made pronunciation errors, they received ½ point if they produced greater than 50% of the correct phonemes and if these phonemes were in the correct order for the target word. When a participant did not know a particular word they were given a semantic cue to facilitate recall. If they claimed that they knew the target word but were unable to retrieve its pronunciation, they were given the initial phoneme or phoneme cluster as a cue. If the participant named the target word following cue(s) they would be given ½ point. If they could not, they would score zero for that target word. It was intended that using this scoring system participants would be differentiated from each other and their total performance score for the language screening tasks would reflect the severity of their aphasia.

4.3 TRAINING SESSION PROCEDURE

Each of the four training sessions incorporated the establishment of a pre-training baseline, the introduction to, familiarisation with and the training and assessment of five novel words. Each session is now explained in detail and the main pathways and modules of the cognitive neuropsychological approach which are accessed during each task are presented in Table 4.1 below. See also Chapter 2 for reference to the cognitive neuropsychology model used in this investigation (Figure 2i and Appendix 2.1).

Table 4.1
Cognitive Neuropsychology Pathways accessed by new vocabulary training tasks

Tasks	**Main representative areas accessed according to the Cognitive Neuropsychology model**
Baseline word/ non-word recognition (listening)	Auditory Phonological Analyses Phonological Input Lexicon
Baseline word/ non-word recognition (reading)	Abstract Letter Identification Orthographic Input Lexicon
Pre-exposure to images and self judgement tasks	Visual/ Object Recognition Semantic System
Listening to new word form details while looking at new image (full word, syllable structure and spelling)	Auditory Phonological Analyses Phonological Input Lexicon Visual/ Object Recognition Semantic System Phonological Output Lexicon Phonological Output Buffer Phonological to Letter Conversion
Looking at written new word form while looking at new image (full word, syllable structure and spelling)	Abstract Letter Identification Orthographic Input Lexicon Semantic System Orthographic Output Lexicon Phonological to Letter Conversion
Repeat new word form (i.e. non-word)	Auditory Phonological Analyses Acoustic to Phonological Conversion Phonological Output Buffer
Listening to new associative links while looking at written words and images	Auditory Phonological Analyses Phonological Input Lexicon Visual/ Object Recognition Abstract Letter Identification Orthographic Input Lexicon Semantic System
Copy word form (i.e. non-words)	Abstract Letter Identification Copy Letters Graphemic Output Buffer

4.3.1 Baseline measures

Prior to each training session, participants performed a listening and reading baseline recognition task. This comprised of five familiar creatures, five novel word forms to be trained and five control non-words (see Appendix 4.6). As the creatures to be trained were novel it was expected that the scores for each task would be zero recognition for these new items. These baseline tasks allowed participants to display their knowledge of already familiar creatures and their ability to recognise non-words. It also provided practise of some assessments that they would undertake following the training period, thereby reducing test artefact effects. Replication of the baseline tasks following training would allow direct observation of vocabulary learned.

4.3.2 Training procedure

Participants were initially introduced to and familiarised with the stimuli during the training procedure through a pre-exposure judgement task. Participants were required to look at each creature's image and state if they recognised them. They were then shown the images again and asked for their opinion/ judgement of the creatures. At this stage participants had not been given any additional information about each creature. If a participant was unable to self-generate an opinion the researcher asked two questions from the following; does the creature look intelligent, honest, happy, angry, scary, friendly? This part of the learning process incorporated the pre-exposure judgement task that would make the semantic basis for further staggered learning (Downes et al, 1997; Kalla et al, 2001) (see section 2.9.2). The training then began using a staggered learning approach where the phonological information (i.e. word form) was introduced (see section 4.3.2.1) and followed by training of the semantic information (word meaning and associated word links) (see section 4.3.2.2).

4.3.2.1 Training of stimuli: phonological information i.e. new word forms

The details of each creature were then introduced, so continuing the staggered learning format. Each creature's image was presented individually as the researcher spoke its name simultaneously. In order to avoid the name being learned as a proper noun rather than a common noun (see section 2.8.3 and 3.6.1.2) the creature was presented alongside another identical creature picture as follows:

- *"Here is a futarg, here is another futarg, that makes two futargs".*
- [The written name was then presented]
- *"The word futarg has six letters, f…u…t…a…r…g".*
- [The researcher pointed to each letter as it was named]
- *"……and has two syllables, fu…targ".*
- [Again the written syllable structure was uncovered along with the spoken presentation]
- Participants were then asked to repeat each name.

4.3.2.2 Training of stimuli: semantic information i.e. new word meanings

Following the presentation of each creature in this manner, a second presentation was made. On this occasion, each creature's skill, habitat and food source were introduced, in both spoken and written form, as follows:

- *"Here is another futarg. Futargs have a special skill – they can freeze their enemies. Futargs live near trees and eat fruit".*

Participants then drew a picture of each creature (while looking at the original picture) to the best of their ability and then copied the creature's name below the picture. The reason for this was two-fold, firstly, it maintained active participation in the learning process and secondly, it incorporated another modality of learning to enhance the memory trace of the items to be learned.

4.3.2.3 Consolidation and rehearsal of learning - Independent learning

Following the second presentation, participants were advised that they were allocated independent learning time (maximum of 30 minutes) to learn as many details as they could about each creature (i.e. name, skill, habitat and food), in whatever manner they chose. The independent learning period incorporated an errorless learning approach to facilitate the learning of the new vocabulary. That is, as participants could immediately check their responses to the various tasks listed below, it reduced errorful memory traces being created. Participants could choose to use any or all of the following options to aid their learning of the stimuli:

- Listen to the details to be learned via a tape-recording (name, skill, habitat and food) as many times as they wished.
- Look at the written and picture representations of the vocabulary (see Appendix 4.7).
- Practise writing the word forms and associated meanings through copying the above material.
- Practise semantic and syllable matching tasks that would be similar to assessments they would later complete, reducing task artefact during the assessment period (see Appendix 4.8).

After all tasks were described to participants the researcher left the room during the independent learning time of 30 minutes (although participants could ask for further direction). At the end of the independent learning period all stimuli were removed from participants.

4.3.3 Procedure for assessment of new learning

Assessments were administered following the independent learning time to establish how many words each participant had learned. As it would be important to facilitate the demonstration of learning by those participants in the main investigation who were unable to say the words accurately, a range of assessments was administered both in spoken and written format. The assessments that were chosen to demonstrate the learning of new words by participants now follow and the main pathways and modules of the cognitive neuropsychological approach which are accessed during each task are presented in Table 4.2 below.

Table 4.2
Cognitive Neuropsychology Pathways accessed by new vocabulary assessment tasks

Tasks	Main representative areas accessed of Cognitive Neuropsychology model
Cold recall	Visual/ Object Recognition Semantic System Phonological Output Lexicon Phonological Output Buffer
Lexical recognition (listening)	Auditory Phonological Analyses Phonological Input Lexicon
Lexical recognition (reading)	Abstract Letter Identification Orthographic Input Lexicon
Syllable matching	Abstract Letter Identification Orthographic Input Lexicon Semantic System Orthographic Output Lexicon
Categorisation	Auditory Phonological Analyses Phonological Input Lexicon Abstract Letter Identification Orthographic Input Lexicon Semantic System
Word-to-picture matching (listening)	Auditory Phonological Analyses Phonological Input Lexicon Semantic System
Word-to-picture matching (reading)	Abstract Letter Identification Orthographic Input Lexicon Semantic System

4.3.3.1 Cold recall

Each creature's image was presented and participants were asked to state all details that they could remember about each one. If any information was omitted the researcher probed for the name, skill, habitat and food source of each creature.

4.3.3.2 *Lexical recognition task*

A tape-recording of the names of the five newly learned creatures along with five familiar creatures and five non-words were randomly presented. Participants answered ‘yes’ when they recognised a word (including those newly learned creatures) and ‘no’ for a word they did not know. This task was then replicated in written form where participants circled those words that were familiar to them (including those newly learned creatures), from a list of five familiar words, five newly learned words and five non-words (replicating the baseline assessment, see section 4.3.1).

4.3.3.3 *Syllable matching task*

The initial syllable of each creature’s name was presented in written format alongside the final syllable of that creature’s name as well as the final syllables of the four other new words learned during that session (see Appendix 4.7). Participants were required to match the beginning of each word with its appropriate ending to form the newly learned word. In the case of tri-syllabic words the first two syllables were presented with the final syllable to be chosen by participants.

4.3.3.4 *Categorisation tasks*

The written words of the four habitats and food sources (see section 4.3.2.2) were arranged on a flat surface. Participants were given each individual creature’s image and were required to point to their appropriate habitat / food source. This task was then replicated using a written form of each creature’s name.

4.3.3.5 *Word-to-picture matching tasks*

Pictures of the five creatures trained that session were arranged on a flat surface. These tasks involved participants choosing the correct creature picture to match the name and skill presented. Each task was presented initially in spoken and then in written form.

4.3.3.6 Scoring system

The scoring of each task varied depending upon the task. As with the preliminary studies' scoring system (see section 3.2.1.6), when a name or skill was recalled correctly the score was one. When a name was incorrect but contained greater than 50% of phonemes / graphemes and were presented in the correct order the score was ½. For example, if the target word 'futarg' was produced as 'putar' it would be allocated ½ as it contains > 50% of the target phonemes and these are in the correct order. When a skill contained two words and one of these words was recalled the score was ½. For example, if the target skill was 'creates storms' and a response consisted of 'storms' or 'creates something' they would be allocated ½ point. Apart from these instances inaccurate names or skills scored zero. The scoring criteria for recalling habitat and food items, auditory and written lexical decision, categorisation tasks, syllable matching and word-picture matching tasks was one for correct and zero for incorrect responses.

The training and assessment procedures (described above) were tested and evaluated before being employed in the main investigation using a number of pilot studies. The participant from pilot study one (P1, see section 4.4) was an adult with normal cognitive and language functioning. Pilot study two (P2, see section 4.5) involved an adult who had had a stroke but was not aphasic. The third pilot study (P3, see section 4.6) assessed if the training and assessment procedures were appropriate for a post-stroke adult with aphasia, for example, in terms of understanding the instructions and tasks involved as well as the timing and number of items in each session. These studies will now be described and evaluated.

4.4 PILOT STUDY ONE

This pilot study assessed the validity of the non-linguistic learning task (stepping-stone route) (see section 4.2.2.2) and evaluated the feasibility of the full training and assessment procedure with an adult with no history of aphasia and with normal cognitive functioning. This evaluation informed the procedure for the main investigation, in terms of the number of sessions required for training and assessment of the new words, the timing of these sessions, the comprehension and clarity of all instructions and any practicalities relating to the presentation of the stimuli.

4.4.1 Participant details

P1 was female (aged 23;09 years) and had completed a total of 17 years in education. She was an allied health professional who worked part-time clinically and part-time as a research assistant. During the period of the study P1 was absent from work due to a relapse in multiple sclerosis. P1 was insistent that she participated in the study at this time, as she wanted to occupy herself during her recovery period. P1 was unable to use her dominant hand for all tasks as a result of her relapse. During this time she also experienced fatigue and was being administered intravenous steroids daily.

4.4.2 Results of P1's performance of screening assessments

As anticipated, P1 scored 100% for the immediate and delayed recall of the non-linguistic learning route (see section 4.2.2.2) as well as for all sections of the CLQT (Helm-Estabrooks, 2001) (see section 4.2.2.1). P1 scored 8 (borderline) on both the anxiety and depression scale, indicating that she was a little more anxious and depressed than would be deemed normal, which may have been due to her illness. The results of the language screening assessments (100% accuracy) demonstrated that P1 was of normal linguistic functioning.

4.4.3 Results of P1's post-training assessment

P1 was trained in all stimuli following baseline measures and was assessed immediately following the independent learning time in all four training sessions (immediate recall). Three days following the last training session, she was assessed again (delayed recall) and in addition one month after this assessment. P1's performance scores will now be presented.

4.4.3.1 Immediate recall

P1's ability to learn the new vocabulary is detailed in Table 4.3 below.

Table 4.3
Pilot Study One
Total raw and percentage correct scores for immediate recall by P1

ASSESSMENTS	SCORE (%)
Repeat new word form	20 (100)
Copy written version of word form	20 (100)
Recognise word form (listening)	20 (100)
Recognise word form (reading)	20 (100)
Cold recall name (spoken)	20 (100)
Cold recall name (written)	20 (100)
Cold recall skill	20 (100)
Cold recall habitat	20 (100)
Cold recall food	20 (100)
Syllable completion (reading)	20 (100)
Word-picture matching name (listening)	20 (100)
Word-picture matching name (reading)	20 (100)
Word-picture matching attribute (listening)	20 (100)
Word-picture matching attribute (reading)	20 (100)
Categorisation attributes (picture)	20 (100)
Categorisation attributes (reading)	20 (100)
Total performance	320 (100)

As presented P1 found no difficulty in learning the new vocabulary and achieved 100% accuracy for the 20 word form and word meaning assessments for all four training sessions. She responded promptly and confidently on all occasions and did not make any semantic or phonemic errors. P1 performed equally well on all assessment tasks and all of the creature details were equally easy for her to learn and recall.

4.4.3.2 Delayed recall

The materials for all stimuli remained with P1 following the final training session. This was to allow P1 to rehearse and consolidate her learning. It also served to reduce possible 'recency effects' contaminating the delayed recall assessments. Five days following the fourth training session, P1 was assessed using the same assessment tasks as with immediate recall to ascertain how much information was retained from the previous week's training. It was thought that this would indicate if the newly learned vocabulary had been retained in long-term storage to be retrieved at a later date. P1 replicated her performance during the immediate recall tasks for all 20 creatures names, skills, habitat and food, again achieving 100% correct on all assessments. All stimuli were returned following this assessment.

4.4.3.3 One month delayed recall

P1 was assessed again one month after the delayed assessment session to ascertain the length of time that the new learning could be retained. She knew that this assessment was planned but did not have any access to the stimuli between the delayed recall assessment and this assessment one month later. As Table 4.4 below indicates, P1 recalled all 20 creature names and skills but had some difficulty recalling the habitat and food items where she recalled 16 out of a maximum of 20. This was also reflected in the categorisation tasks for habitat and food. P1's performance indicated that the training and assessment procedure not only facilitated immediate short-term memory recall but also retention and retrieval from long-term memory.

Table 4.4
Pilot Study One
Total raw and percentage correct scores for one month delayed recall by P1

ASSESSMENTS	SCORE (%age)
Cold recall name (spoken)	20 (100)
Cold recall name (written)	20 (100)
Cold recall skill	20 (100)
Cold recall habitat	16 (80)
Cold recall food	16 (80)
Recognise word form (listening)	20 (100)
Recognise word form (reading)	20 (100)
Syllable completion (reading)	20 (100)
Word-picture matching name (listening)	20 (100)
Word-picture matching name (reading)	20 (100)
Word-picture matching skill (listening)	20 (100)
Word-picture matching skill (reading)	20 (100)
Categorisation habitat and food (picture)	17 (85)
Categorisation habitat and food (reading)	17 (85)
Total performance	266 (83)

4.4.3.4 Timing of sessions

The length of time that P1 required for the training and assessment of the stimuli is presented in Table 4.5 below by session.

Table 4.5
Pilot Study One
Timing of all sessions for P1

Task		**Total time**
Pre-training baseline assessments		60 minutes
Each training session -		
presentation of stimuli	*20 minutes*	
independent learning time taken	*10 minutes*	
assessments	*15 minutes*	45 minutes
Delayed assessments		20 minutes
One month delayed assessments		40 minutes

While 30 minutes was allocated for 'independent learning', P1 only used 10 minutes for each training session. During this time she played the pre-recorded audio cassette and looked at the written and visual information that gave details of the new vocabulary. She also practised completing the assessments (see section 4.3.2.3). It was noted that it took P1 twice as long to recall the information from long-term memory for the one month delayed recall (40 minutes) than the initial delayed recall (20 minutes) (see Table 4.5). This indicated that although P1 still had memory traces for the new vocabulary it was not as readily accessible to her following this one month delay.

4.4.4 Methodological issues

A number of methodological issues arose over the course of pilot study one. They were mainly in relation to the procedure and to the content of the stimuli in the training and assessment sessions. The issues will now be discussed under their relevant headings and include the presentation of the stimuli, addition and amendments of materials and the consolidation of learning.

4.4.4.1 Presentation of stimuli

The presentation of the stimuli in pilot study one was less smooth than desired therefore this was re-evaluated and amended for later studies. Instead of presenting the picture, name, skill, habitat and food for each creature as separate individual items, all stimuli for each creature were displayed on a single A4 sheet (see Appendix 4.8). Each stimulus was to be revealed at the appropriate moment making the presentation smoother and less prone to possible error. It was also decided to audio record all participants' responses to allow for more naturalistic researcher/ participant interaction. When presenting the stimuli for word-picture matching tasks during the delayed recall assessment, 20 items was deemed too many for participants to choose from. A choice of five items was considered an adequate number. It was decided to chunk all words that were originally presented together during the training session. This reflected the general consensus of information being learned in chunks therefore facilitating easier access when recalling this information under the same conditions as originally learned.

4.4.4.2 Addition / amendment of materials

While P1 was able demonstrate her learning in spoken format, participants with aphasia may not have adequate speech to do so. Therefore, to further facilitate demonstration of learning of the novel words (during the cold recall task) by participants with aphasia, it was decided that participants would also be required to recall the new words in written form and (if required) their skill, habitat and food source. This would also facilitate comparison of participants' written output of the new vocabulary with their spoken performance, as well as with their written performance on already familiar words. Instead of using the same five familiar creatures as stimuli for each session's lexical recognition task (spoken and written), a different set of familiar creatures would be used for each session. The reason for this amendment was two-fold; firstly, it would use the same combined amount of stimuli in each session and would be the same number of items in the delayed recall assessment stimuli (i.e. 20 familiar words, 20 newly learned words and 20 non-words) (see Appendix 4.6). Secondly, it would offer participants more opportunity to succeed (assuming they recognised the familiar words).

It was also felt that there was a gap in the screening assessment where there was no sample of connected speech. This would be important for describing the language of participants with aphasia. The narration of the Cinderella story in both spoken and written form is a widely used method of obtaining a sample of connected speech (Rochon, Saffran, Berndt and Schwartz, 2000; Saffran, Berndt and Schwartz, 1989). While there are methods of analysing these speech samples in depth, this study did not employ them for two reasons. Firstly, the main investigation trained and assessed single words rather than sentence format. Secondly, the sample was simply to further describe the particular language difficulties that participants with aphasia presented with, which may not be obvious with single word utterances. Participants with aphasia would be asked to narrate the story of Cinderella in spoken and written format.

4.4.4.3 Consolidation of learning

The written and auditory stimuli used during the independent learning phase remained with P1 between the immediate and delayed recall phase to allow her to rehearse and consolidate her learning. This aimed to reduce the ‘recency effect’ phenomenon where a person was most likely to recall the last items that they have been exposed to, which in this study would be the five creatures from session four. However it was not possible to control for the time interval between the final practise of the stimuli by P1 and the actual delayed assessment. The function of the delayed assessment was to assess the retention of the learned information by each participant following a break from the training sessions. Therefore, if a participant practised the stimuli immediately prior to the assessment it could not categorically be called ‘delayed’ recall. Because of this concern, it was decided not to leave the materials with participants for the main investigation. However the problem of the ‘recency effect’ phenomenon remained along with the fact that rehearsal and consolidation of learning was a necessary requirement for the learning process (see section 2.8.5.3). It was decided that following a short break at the end of session four, a brief revision of all 20 creatures learned would be given to all participants. This would involve participants looking at the stimuli and listening to all 20 creatures details (on pre-recorded audio tape). It was felt that consolidation and rehearsal of learning occurred during the independent learning period of the training sessions and so extra time with the stimuli was not considered necessary for learning to occur.

4.4.5 Summary of pilot study one

Pilot study one evaluated the non-linguistic learning task (stepping-stone route) (see section 4.2.2.2) that was adapted from Evans et al (2000). P1 performed the task with 100% accuracy, indicating that she could follow the instructions for the task and assessment procedure successfully, and that the task itself could be learned. In the absence of a more standardised non-linguistic learning task, it was decided to use this task as part of the screening assessment for the main investigation.

This pilot study also evaluated the training, assessment and scoring procedures for the main investigation with an adult of normal cognitive and linguistic functioning. However, while the participant's language and cognition were normal, her emotional and medical status (including fatigue and use of her non-dominant hand) during the pilot phase mimicked many limitations experienced by people with aphasia. Therefore this study was more informative than if P1 had been a fully functioning healthy participant. The study endeavoured to ascertain the number and timing of training and assessment sessions, the details of which are displayed in Table 4.3. The number of sessions that were required was as anticipated (i.e. six sessions), and the number of items to be learned was appropriate for the time allocated, i.e. five creatures to be introduced, trained, learned and assessed within approximately one hour. While the estimated time required for independent learning was 20 minutes less than anticipated, it could not be assumed that participants with aphasia would be able to learn this novel linguistic information during the same period of time. This time frame was further evaluated when compared with the performance of the post-stroke participant with aphasia in pilot study three (see section 4.6). The instructions were clear and comprehensive with an example of each task using an already familiar creature being useful in demonstrating all tasks and assessments.

A number of methodological issues arose for both the presentation and content of the stimuli. To address this, the methodology was amended (see section 4.4.4) and was considered suitable for teaching and assessing new vocabulary to an adult with normal cognitive and linguistic abilities. However, the aim of the main investigation was to assess if adults who had language impairment, as a result of a stroke could learn this new vocabulary. To ensure that any difficulties encountered by post-stroke adults in learning the new vocabulary was a reflection of their impaired language rather than some other variable of post-stroke impairment pilot study two was carried out with participant P2 who had a stroke but was not aphasic.

4.5 PILOT STUDY TWO

This study used the amended methodology (from pilot study one) to appraise the procedure with an adult who had a stroke but did not have aphasia. It was expected that the participant would be able to demonstrate learning of the new vocabulary presented during the training procedure. Also the timing of all sessions and assessments were evaluated with an adult who had experienced a stroke.

4.5.1 Participant details

P2 was recruited from a local Chest, Heart and Stroke Association group. She was female (aged 59;06 years) and was 20 months post-stroke at the time of the study. She completed 17 years in education and did not seek employment following graduation. P2 lived with her husband and had no physical impairment or aphasia following her stroke, although there was a mild dysarthric quality (see section 2.2) to her speech. She reported that she mainly experienced memory difficulties.

4.5.2 Results of P2's performance on screening assessments

The screening assessments from pilot study one (see section 4.2) were administered to P2. Her performance on the subtests of the CLQT (Helm-Estabrooks, 2001) (see Table 4.6) indicated that P2's attention, executive function, language and visuospatial skills were within normal limits (WNL) while memory and clock drawing skills were both mildly impaired.

Table 4.6
Pilot Study Two
Raw scores and severity rating for the CLQT (Helm-Estabrooks, 2001) by P2

Attention	Memory	Executive function	Language	Visuospatial skills	Clock drawing severity
180	152	28	29	98	11
WNL	Mild	WNL	WNL	WNL	Mild

P2 demonstrated her ability to learn non-linguistic information by achieving 100% accuracy on the stepping-stone maze route (see section 4.2.2.2) for immediate recall and a score of 78% on the 3-minute delayed-recall. P2 scores on the HADs (Zigmond & Snaith, 1983) self-rating scale indicated that she was feeling both anxious (score = 14) and depressed (score = 18). P2's language screening assessment results are displayed in Table 4.7. Her 100% performance confirmed that she did not present with aphasia.

Table 4.7
Pilot Study Two
Raw and percentage correct scores for P2's language screening assessments

Task	Words	Non-words	Shapes	Pictures
Repetition	8 (100%)	8 (100%)		
Auditory lexical decision	8 (100%)	8 (100%)		
Reading	8 (100%)	8 (100%)		
Naming				12 (100%)
Visual lexical decision	8 (100%)	8 (100%)		
Categorisation	15 (100%)		15 (100%)	15 (100%)
Spelling	6 (100%)	6 (100%)		

4.5.3 Results of P2's post-training assessments

P2 was trained in all stimuli and assessed immediately following the independent learning time in all four training sessions (immediate recall) to demonstrate the learning of the new vocabulary. Five days following the last training session, she was assessed again (delayed recall) to assess the retention of this new learning. P2's performance scores will now be presented.

4.5.3.1 Immediate recall

Table 4.8 below displays P2's ability to learn the new vocabulary. While the performance was not as successful as P1's in pilot one (Table 4.3), P2's learning ability reflected the variability of learning by healthy normal adults (see section 3.7).

Table 4.8
Pilot Study Two
Total raw and percentage correct scores for immediate recall by P2

ASSESSMENTS	SCORE (%)
Repeat new word form	20 (100)
Copy written version of word form	19 (95)
Cold recall name (spoken)	14 (70)
Cold recall name (written)	16 (80)
Cold recall skill	7 (35)
Cold recall habitat	18 (90)
Cold recall food	18 (90)
Recognise word form (listening)	20 (100)
Recognise word form (reading)	20 (100)
Syllable completion (reading)	14 (70)
Word-picture matching name (listening)	16 (80)
Word-picture matching name (reading)	18 (90)
Word-picture matching skill (listening)	17 (85)
Word-picture matching skill (reading)	18 (90)
Categorisation habitat/food (picture)	19 (95)
Categorisation habitat/food (reading)	17 (85)
Total performance	271 (85)

P2 recalled 14 (70%) of the new words in spoken format and 16 (80%) in written form. Overall, she achieved 85% success in completing the assessment tasks correctly. The task that P2 found most difficult was to recall the creatures' skills (n=7- 35%). During the independent time P2 used the full 30 minutes to consolidate her learning but chose not to complete any of the assessment type tasks but rather looked at the stimuli silently. Following the assessment period of the fourth session, P2 had a break of approximately 10 minutes and then listened to the tape recording of the 20 creature details as well as looking at the written creatures.

4.5.3.2 Delayed recall

Table 4.9
Pilot Study Two
Total raw and percentage correct scores for delayed recall by P2

ASSESSMENTS	SCORE (%)
Cold recall name (spoken)	2 (10)
Cold recall name (reading)	3 (15)
Cold recall skill	0
Cold recall habitat	1 (5)
Cold recall food	1 (5)
Recognise word form (listening)	18 (90)
Recognise word form (reading)	14 (70)
Syllable completion (reading)	16 (80)
Word-picture matching name (listening)	8 (40)
Word-picture matching name (reading)	6 (30)
Word-picture matching skill (listening)	7 (35)
Word-picture matching skill (reading)	8 (40)
Categorisation habitat/ food (picture)	7 (35)
Categorisation habitat / food (reading)	6 (30)
Total performance	97 (30)

Five days after the fourth training session, P2 was assessed using the same assessment tasks as with immediate recall to ascertain how much information she had retained from the previous week's training. As can be seen from Table 4.9 above, P2 recalled 30% of total items assessed, retaining 36% of the knowledge that she had learned in the training sessions (immediate recall assessments).

In comparison to P2's ability to recall the new information, P1 recalled 100% of the new information after a delay of five days and 83% recall after a further one-month delay. This could be a reflection of the longer consolidation time given to P1 between the fourth training session and the delayed recall (see section 4.4.3.2) or possibly a reflection of P2's reported long-term memory difficulties. It was decided not to request a one-month delayed recall session as firstly, there was a substantial reduction in P2's ability to retain the learned information. Secondly, the focus of the investigation was on the learning of new vocabulary rather than how long a person could store this new learning for and a further assessment was considered to be more a memory than a learning test.

4.5.3.3 Timing of sessions

The timings of the screening assessment session, presentation of stimuli and delayed recall session were the same as with P1 (see Table 4.5). P2 chose to take the full 30 minutes for each independent learning session to rehearse and consolidate her learning.

4.5.4 Summary of pilot study two

Although P2 volunteered to participate in the investigation her approach to learning was negative and throughout the training sessions claimed that she would not be able to learn or remember anything. Her self-rating of depression (see section.4.5.2) reflected this overall negative outlook. During the independent learning time P2 did not use observable learning strategies, choosing only to look at the creature details silently for the 30-minute duration. Table 4.8 demonstrated that P2 did learn some of the new vocabulary and could demonstrate this learning during immediate recall. This pilot study confirmed that a post-stroke adult with no aphasia could demonstrate the learning of new vocabulary. On the other hand, Table 4.9 indicated that someone who has cognitive impairments, in P2's case memory problems (see section 4.5.2), might find it difficult to consolidate and retain this information for future recall. No methodological issues arose during this pilot study, and the presentation and assessment stimuli were appropriate. The full methodology was then administered with an adult who had residual aphasia following a stroke in pilot study three below.

4.6 PILOT STUDY THREE

This study evaluated the suitability of methodology (as employed in pilot study two, see section 4.5) for the training and assessment of new vocabulary with an adult who had language difficulties following a stroke. The timing of the sessions was also assessed in light of possible delayed responses due to language difficulties. To reiterate, this pilot study presents data evaluating the suitability of the methodology for a person with aphasia rather than the participant with aphasia's ability to learn the stimuli. Therefore data gathered during pilot study three relating to P3's language abilities and his learning performance are not presented here, but are included in the reporting of the main investigation in Chapter 5 (see section 5.6).

4.6.1 Participant details

P3 was recruited for participation in this investigation through his speech and language therapist. He was male (aged 64;04 years) and was seven months post-stroke at the time of the investigation. Speech and language therapy records noted that P3 had expressive aphasia resulting from a left fronto-parietal infarct. At the time of the study, P3 was having a break following a block of weekly speech and language therapy. P3 lived with his wife and was fully mobile with no residual paresis but had post-stroke epilepsy which was managed by medication. He was a retired pharmacist who had completed 20 years in education (encompassing two undergraduate degrees and a post-graduate degree). P3 described his language difficulties as frustrating, as some days his speech was fluent and on others he was unable to speak intelligibly. He stated that he knew the words he wanted to say, but found great difficulty pronouncing them. He reported that he did not experience any memory processing difficulties and his reading and writing skills, while impaired, were gradually improving.

4.6.2 Training and assessment sessions

P3 was eager to succeed and showed consistent attention to all procedures. He followed all instructions easily and completed all tasks with no apparent difficulties. P3 participated in the pre-training screening assessments, training and immediate recall of all four sessions, and also delayed recall tasks. He reported these procedures to be straightforward and had no difficulties with the instructions or tasks.

Table 4.10
Pilot Study Three
Timing of all sessions for P3

Task	Total time
Pre-training baseline assessments	60 minutes
Training session one	60 minutes
Training session two	60 minutes
Training session three	50 minutes
Training session four	65 minutes
Delayed assessments	50 minutes

P3 utilised the full 30 minutes allotted for independent learning for each session and the length of time required for all training and assessments is presented by session in Table 4.10. A number of methodological issues arose following the training and assessment sessions and are now discussed.

4.6.3 Methodological issues

A number of methodological issues emerged following the immediate recall assessment of pilot study three. Firstly, it was apparent that P3 knew some of the creature names but was unable to pronounce them accurately. While he often (eventually) managed to speak the words, albeit with phonological errors, other participants with aphasia may not be able to do so, because of severe spoken and/or written difficulties. A task was devised for the main investigation that would tap into the phonological knowledge of the word forms of the new vocabulary. The task chosen was a picture-syllable matching task, where a picture of an object (in this case a picture of a creature) would be shown to the participant and they would indicate how many syllables the creature's name contained by pointing to the number one, two or three (tapping into the phonological output lexicon). This information would be taught to participants during the training sessions. To practise this task some pictures of familiar items would be shown to participants (for example, apple, banana, tomato etc.) to ensure that any task difficulty artefact was eliminated.

At this stage it was also considered that it would be advantageous to observe if participants could read aloud the new words that they had learned. Following the errorless learning approach this would only be appropriate after training, otherwise, it could give rise to 'errorful' memory traces being established if done as a baseline measure. The words could then be compared to the participant's ability to read words and non-words which were gathered during the pre-training screening assessments. These additional tasks were piloted on P3 during the delayed recall assessment and found to be useful assessment tools for the main investigation.

4.6.4 Summary of pilot study three

The amended methodology from pilot study one was evaluated to ascertain its suitability for participants with post-stroke aphasia. The outcome confirmed the suitability of the training and assessment procedures. P3 understood all instructions and completed all of the required tasks. Comparing the time used by P1 (see Table 4.5) and P3 (see Table 4.10), the pre-training screening assessment took the same amount of time (1 hour). P1's four training sessions lasted 45 minutes each whereas P3's varied between 1 hour for sessions one, two and four and 50 minutes for session three. The delayed assessment took 50 minutes whereas P1's only took 20 minutes. However, two additional tasks were inserted into P3's assessment (picture-syllable matching and reading creature names aloud). P3 used more independent learning time to learn the creatures than P1, which was also reflected in the longer time required for each session. On the whole, the time required by P3 fell within the time originally allotted for the sessions. The process of this study confirmed that the methodology employed was appropriate for an adult with aphasia.

As discussed, two additional assessment tasks were inserted into the delayed assessment procedure for P3 (see section 4.6.3). The picture-syllable matching task facilitated the demonstration of word form knowledge without the requirement for speech, thus facilitating the demonstration of learning at the phonological output level. The final methodology for the main investigation included this task during the immediate as well as the delayed recall. Participants also read the creature names aloud during both the immediate and delayed assessments. As this study incorporated an errorless learning approach it was essential to ensure that any errors made during the training phase were noted and corrected. It was noted that P3 sometimes found it difficult to repeat a new word without first making errors. On most occasions he was able to correct his pronunciation. However, not all participants with aphasia would be able to correct their speech regardless of the number of attempts. Therefore, if a participant repeated a word incorrectly they would be corrected immediately and asked to repeat it again following the modelling of the target word. If following two attempts participant were still unable to correctly repeat the word, they would be asked not to repeat the word again, but to listen to the researcher saying the word twice. The level of frustration experienced by P3 when he was not succeeding, particularly during the delayed recall session, along with the percentage of items being forgotten at this stage (see section 5.6) led to the decision not to proceed with a one-month post-training assessment for participants in the main investigation. The final methodology that was employed in the main investigation is presented below. It is discussed in relation to the single word processing model that was chosen to support the methodology for facilitation of learning the new vocabulary (see section 2.9.3).

4.7 THE METHODOLOGY FOR THE MAIN INVESTIGATION

The outcome of the pilot studies in this chapter culminated in the completion of the final methodology. This would be employed to facilitate the learning of new vocabulary and enable the demonstration of this new learning by main investigation participants. The various tasks involved in the pre-training screening assessments, the procedure followed during the four training sessions and the immediate and delayed recall assessment of this new learning are summarised in Chapter 5 (see Figure 5.1, section 5.5.2).

As discussed in Chapter 2, the cognitive neuropsychology approach was chosen to support the learning and assessment methodology for the main investigation (see section 2.9.3). The importance of the assessment procedure enabling participants with all levels of severity of aphasia to demonstrate any learning has been discussed throughout the development of the methodology. The cognitive neuropsychology model was considered an appropriate model to this facilitate the various levels of the training and assessment procedure.

The way the cognitive neuropsychological model was used to support the design of the training and assessment tasks and procedures are discussed in the relevant sections of 4.3 and summarised in Figure 4ii below.

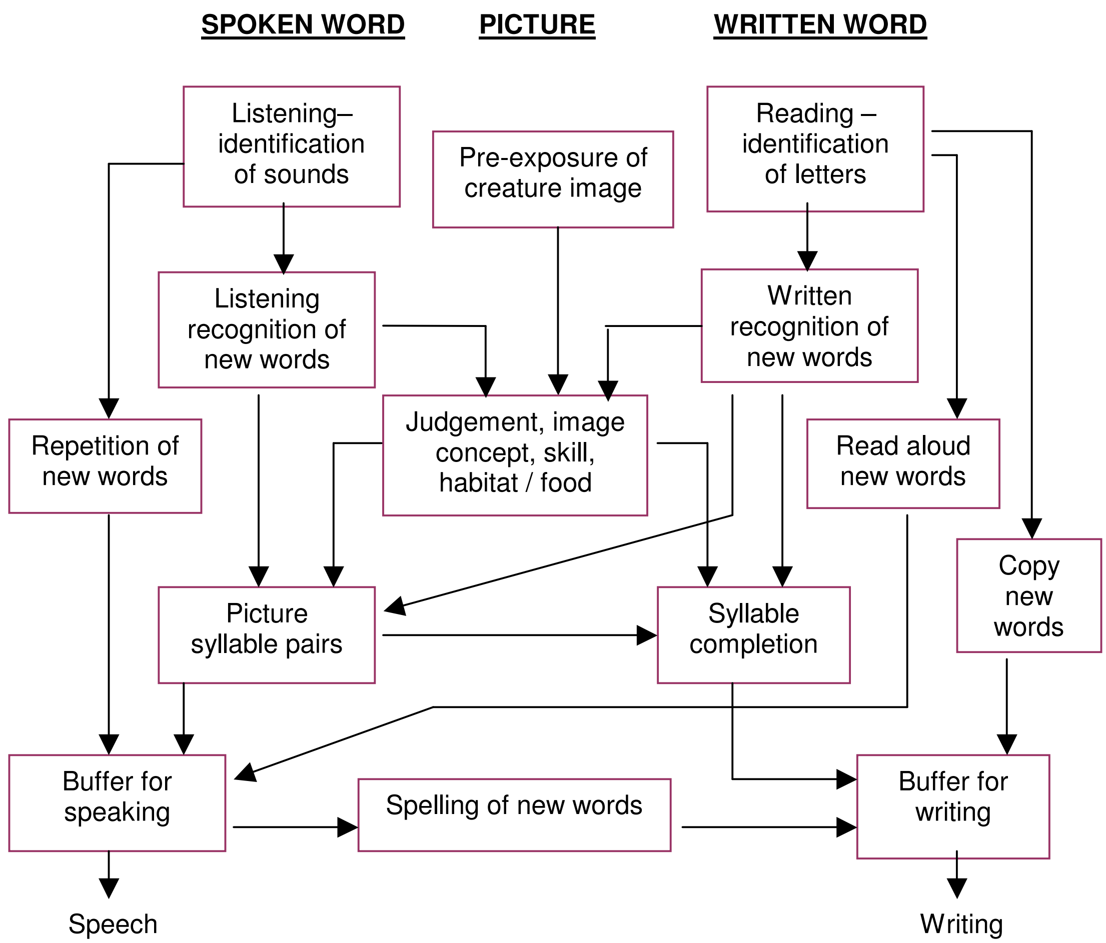


Figure 4ii
Support of cognitive neuropsychological model for learning procedure

4.8 CHAPTER SUMMARY

The three pilot studies described in this chapter narrate the evolution of the methodology to its final completion. The screening assessments were evaluated for use in the main investigation. The HADs self-rating scale (Zigmond and Snaith, 1983) was considered adequate for evaluating the emotional well-being of participants in terms of anxiety and depression, as the scores appeared to reflect participants' report of how they felt at the time of the studies. All participants in the main investigation completed the HADs with the help of the researcher who read the individual statements aloud to ensure that those participants who presented with acquired reading difficulties as a result of their stroke understood the task. The CLQT (Helm-Estabrooks, 2001) appeared to be adequate in screening the cognitive abilities and difficulties of participants. The 'stepping-stone route' appeared to be appropriate for assessing non-verbal learning tasks as based on Evans et al. (2000). Additionally, the language screening assessment was considered to be sufficient to differentiate between varying degrees of aphasia severity and would be used in conjunction with the language screening sub-test of the CLQT (Helm-Estabrooks, 2001).

The stimuli and methodology proved successful in training and assessing participants in the acquisition of new vocabulary. Participants P1 and P2 demonstrated that it was possible to learn this novel vocabulary (see section 4.4.3.1 and 4.5.3.1) and retain it in long-term memory (see section 4.4.3.2 and 4.5.3.2). The methodology was also suitable for training and assessing participant P3 who presented with aphasia (see section 4.6) and therefore considered suitable for training and evaluating the ability of participants with aphasia to learn new vocabulary in the main investigation. As reported by De Groot and Keijzer (2000) participants were motivated to learn the nonsense vocabulary (see section 2.8.5.1) and reported that they found it enjoyable and that the novelty help maintain their attention. The methodology was discussed in relation to the robustness of the cognitive neuropsychology model in supporting the methodology for the learning and assessment procedure. The effectiveness of the cognitive neuropsychology approach in supporting the main investigation and its strengths and weaknesses are discussed in Chapter 6 (see section 6.5).

The next chapter addresses the question of whether post-stroke young adults can learn new vocabulary despite having language difficulties. Chapter 5 presents the findings of the main investigation and describes the profiles of 12 post-stroke adults with aphasia (six male and six female) who participated in the main investigation. As discussed, various factors are thought to affect the outcome of aphasia rehabilitation and it is possible that these factors may also influence the learning of new vocabulary (see section 2.6). Therefore, the main investigation also evaluated the contribution of each participant's pre-existing characteristics to their learning abilities. These included personal attributes (age, education, employment, months post-stroke and emotional status); cognitive abilities (attention, memory, executive function and performance on the non-linguistic learning task) and also their language abilities (word recognition, categorisation, reading, naming and spelling). This information was utilised to explain the ability (or inability) of each participant to learn the new vocabulary and additionally, to enable predictions to be made which may inform speech and language therapists regarding which adults would be most successful in learning new linguistic information and why.

Chapter 5 Main Investigation

5.1 INTRODUCTION

The pilot studies (Chapter 4) have demonstrated that the novel stimuli and procedure were suitable for the training and assessment of new vocabulary learning by healthy adults and post-stroke adults with and without aphasia. The main investigation reported in this chapter whether adults with aphasia could learn new vocabulary. As previously discussed (see section 2.7) this knowledge could inform any theory of rehabilitation as it is currently not known if aphasia rehabilitation merely facilitates the accessing of previously known information which is now inaccessible due to cortical damage or if new learning is involved in the therapeutic process. This information could also have implications for the methods and stimuli employed in aphasia rehabilitation.

This chapter reports the recruitment criteria of participants for the main investigation and outlines the procedure as developed through the process of the preliminary studies (Chapter 3) and pilot studies (Chapter 4). The results are divided into three main sections. Firstly, the findings relating to the main research question i.e. whether post-stroke adults with aphasia (<65 years) can learn new vocabulary are presented for the 12 participants as a group (see section 5.3). Following the assumption that the aphasic population is however heterogeneous in nature (see section 2.2) a case series format was followed and so the findings are then presented individually for each participant on a task-by-task basis. The profile of each participant is also presented at this stage to give an overview of relevant personal and medical information. This includes pre-training measures, in particular, emotional well-being as self-rated by the HADs assessment (Zigmond and Snaith, 1983), cognitive abilities as measured by the CLQT (Helm-Estabrooks, 2001) and the devised non-linguistic learning task (see section 4.2.2.2) as well as each participant's language abilities from both the CLQT (Helm-Estabrooks, 2001) and the devised language screening assessment (see section 4.2.3). As the literature indicates various factors that are thought to impact upon recovery from aphasia (see section 2.6) it was considered useful to examine some of these factors in relation to the findings for this population sample as a whole using hierarchical cluster analyses and other statistical analyses (see section 5.18). Participant P3 from the pilot studies (see section 4.6) was not included in these group analyses as he did not complete all tasks for the immediate recall assessments. The tasks and stimuli were also considered in terms of their contribution to the scores and inter-reliability of the four learning sessions is noted (see section 5.18.3 and sub-sections). The final section of this chapter summarises these analyses.

5.2 METHOD

5.2.1 Participant criteria and selection

The inclusion criteria for participation in this investigation were chosen in order to eliminate as many contaminating factors as possible and are listed and discussed below.

- In order to eliminate possible age-related artefacts participants were aged 65 years or younger. This is in line with the division in the National Health Service (NHS Scotland, 2002), which determines that older adults are those aged 65 or older. Young adults are therefore those aged 64 or younger.
- The potential of rehabilitation for the participant population was considered to be an important factor therefore any language disability presented by participants was as a result of a stroke. This also ensured that any aphasia would not be transient or progressive (see section 2.2). The severity and type of aphasia was not specified in order to obtain and analyse performance from people with a wide variety of language difficulties.

- The medical stability of participants was considered essential to ensure that their attention was focussed on the investigation at hand rather than ongoing personal ill-health.
- In order to reduce extraneous influences on the ability to learn, participants did not have any history of mental illness, progressive illnesses or illegal substance abuse.

Prior to recruitment, ethical approval was secured from the Lothian and Fife NHS Trusts. Recruitment of participants was mainly through communication with trust managers and speech and language therapists where the investigation was discussed and potential participants were noted. Information sheets (see Appendix 5.1) describing the investigation and participant consent forms (see Appendix 5.2) were forwarded to each manager. Completed consent forms were returned on behalf of consenting participants by speech and language therapists. The participants with aphasia in the main investigation originally numbered 14, however one participant had severe visual impairments and was unable to participate in the screening assessments and another participant began the training but unfortunately became ill and had to withdraw from the investigation after two training sessions. Of the remaining 12 participants, nine were recruited through their speech and language therapists. One participant was recruited through communication with a local college, which educates people with disabilities. A further two participants were recruited from an informative talk about the investigation at the local Chest, Heart and Stroke Association. Of these 12 participants there was no participant attrition for the four training sessions, however, two participants (C10 and C11) declined to partake in the delayed recall assessment tasks.

5.2.2 Procedure

<u>Pre-training screening assessments</u>

Cognitive abilities - Cognitive Linguistic Quick Test (see section 4.2.2.1)

Nonverbal learning ability - Non-linguistic learning task (see section 4.2.2.2)

Speech and language abilities - Repetition of words and non-words, listening and reading lexical decision confrontation naming, categorisation tasks (shapes, pictures and words), reading aloud, written spelling of words and non-words (see section 4.2.3)

Emotional well being - Hospital Anxiety and Depression Scale (HADs) (see section 4.2.1)

Sample of connected speech - Narration of Cinderella story (spoken and written) (see section 4.4.4.2)

<u>Training session procedure</u>

Baseline measures - Participants identify familiar and non-familiar words when listening and reading lists of words (see section 4.3.1)

Introduction and familiarisation with stimuli – Pre-exposure judgement task (see section 4.3.2)

Training of stimuli - Phonological information (new word forms) (see section 4.3.2.2)
Semantic information - (new word meanings) (see section 4.3.2.2)

Consolidation of learning - Independent learning time (maximum 30 minutes) with options (i) listen to audio cassette, (ii) look at stimuli and / or (iii) practise tasks (see section 4.3.2.3)

<u>Assessment of new learning</u>

<u>Immediate recall</u> (testing only those items learned in that particular session)

<u>Delayed recall</u> (testing all 20 creatures 3-5 days following the final training session)

Cold recall – recall of names (spoken and written), skills, habitat and food of each creature while looking at Its image (see section 4.3.3.1)

Lexical decision – identifying familiar and non-familiar words when listening and reading lists of words (see section 4.3.3.2)

Syllable matching – linking written syllables to form the new word forms (see section 4.3.3.3)

Categorisation tasks – linking each creature (picture and reading) to habitat / food (see section 4.3.3.4)

Word-picture matching tasks – listening and reading words and matching them to correct creature image (see section 4.3.3.5)

Picture-syllable matching – choosing number of syllables in creature's name from looking at its image alone (see section 4.7.3)

Read aloud – read aloud new word forms (see section 4.7.3)

<u>Revision of all 20 creatures</u> - After training session four was completed participants looked at all 20 creatures that they had learned that week and listened to the details on an audio pre-recording

Figure 5i
Final methodology for the main investigation

The methodology for the training and assessment of the new vocabulary for the main investigation was discussed in detail in Chapter 4 (see section 4.7) and is summarised again in Figure 5i above.

5.3 MAIN INVESTIGATION FINDINGS

The main research question of this investigation was to ascertain if adults with aphasia could learn new vocabulary despite having language impairments as a result of their stroke. As the literature has suggested that adults with aphasia have demonstrated the ability to learn other types of new information (see section 2.8.5.3) a hypothesis was formed as follows:

Hypothesis one	Adults with aphasia will demonstrate the learning of new vocabulary

This hypothesis was addressed by simply observing the total raw scores for each participant's performance on the assessments immediately following the training session (immediate recall). The degree of ability to learn the new vocabulary was assessed by totalling the raw scores for each assessment. Details of performance on all assessments are presented in individual profiles (see section 5.5 –5.16). The highest possible score for each individual was 320 being the total maximum score for the assessment tasks (immediate and delayed recall). The exception to this was participant P3 whose highest possible score was 280 as he was not assessed with all immediate recall tasks during the methodological development in the pilot studies (see section 4.6.3).

The immediate recall totals for each participant are presented in Table 5.1 below. For convenience, participants are numbered according to immediate recall score. As can be seen, the results support the hypothesis that these 12 adults, although presenting with post-stroke aphasia, all demonstrated some ability to learn new vocabulary. There was a large range of learning ability spanning from the lowest percentage correct of 15%, to the highest percentage correct of 99%.

Table 5.1
Raw and percentage scores for immediate recall tasks (12 participants)

Participant	Raw score (total = 320)	Percentage correct
C1	318	99
P3*	253	90
C2	284	89
C3	266	83
C4	215	67
C5	199	62
C6	189.5	59
C7	155	48
C8	154.5	48
C9	76	24
C10	50	16
C11	49	15

*P3's total possible raw score is 280 (refer 4.6.3)

As the various assessment tasks facilitated the demonstration of this learning in ways other than and in addition to spoken and/or written responses the findings were considered to be a reflection of participant ability to learn the new words. However, the more ability a participant had for spoken and/or written communication the more points they were likely to achieve, perhaps placing participants who were unable to demonstrate their learning in spoken or written format at an instant disadvantage. When the assessment tasks that did not require spoken and written responses were subtracted from the total raw scores a slightly different picture emerged. Table 5.2 presents the ranking of participants using these amended raw scores and percentages. Although individual rankings of participants changed, the original top three participants (i.e. C1, P3 and C2) remained the top three scorers and the lowest scoring participants (i.e. C9, C10 and C11) remained the lowest scoring following the removal of the tasks requiring spoken and written responses.

Table 5.2
Raw and percentage scores for non-verbal assessment tasks for immediate recall (12 participants)

Original ranking	Non-verbal ranking	Word-picture Matching (name)		Word-picture Matching (skill)		Syllable completion	Total	
		Listen	Read	Listen	Read	Read	N	%
C1	C1	20	20	20	20	20	100	100
P3	C2	20	20	20	20	20	100	100
C2	P3	20	20	18	20	16	94	94
C3	C4	20	20	20	18	16	94	94
C4	C3	16	15	20	18	20	89	89
C5	C5	18	14	11	8	15	66	66
C6	C7	11	11	11	13	13	59	59
C7	C6	8	8	11	15	15	57	57
C8	C8	12	13	11	6	11	53	53
C9	C9	3	5	7	7	9	31	31
C10	C10	9	8	7	1	4	29	29
C11	C11	1	8	3	4	4	20	20

The original immediate recall total (i.e. including spoken and written tasks) was therefore considered reflective of the overall ability to learn the new vocabulary by participants. Therefore the original raw scores will be used for all further analyses.

In order to observe if the learning demonstrated by participants in immediate recall tasks was retained in long-term memory, participants were re-assessed three to five days following the final training session. Ten participants agreed to participate in the delayed recall assessment tasks (P3 and C1-C9). Details of performance on all delayed recall tasks are presented in the individual participant profiles (see section 5.5 – 5.16). The delayed recall totals for each participant are presented in Table 5.3 below. Participants were listed according to their performance in descending order. The raw scores indicate that people with aphasia could retain information from the newly learned vocabulary three to five days following training.

Table 5.3
Raw and percentage scores for delayed recall tasks (10 participants)

Participant	Raw score (total = 320)	Percentage correct	Percentage of items retained from Immediate recall
C1	263.5	82	83
C3	210.5	66	80
C2	188	59	66
P3*	169	53	49*
C5	159	50	80
C4	144	45	67
C6	132	41	70
C7	110.5	35	71
C8	102	32	66
C9	56	17.5	74

*as P3 completed the reading aloud and picture-syllable matching in the delayed recall assessment only (4.6.3), these figures were deducted from his scores in Table 5.2 (i.e. 169 – 16 – 17 / 280) to enable computation of percentage retained from immediate recall.

As with the immediate recall scores there was wide variation in performance, with the percentage achieved ranging from 17.5% (raw score 56 from a possible maximum score of 320) to 82% (raw score 263.5 from a possible maximum score of 320) correct. The percentage of items recalled from immediate recall assessments was compared with the information recalled from the delayed recall assessments. The percentage of retained learning ranged from 49% to 83% of information. This indicated that much of this learning was retained from the training sessions. It was observed that the ranking position of participants in the immediate recall was not the same for either delayed recall or percentage of learning retained. Table 5.4 below presents the ranking of participants for immediate recall, delayed recall and the percentage of knowledge retained from the original training sessions. Participants were listed according to their performance in descending order. Participants who scored highest in immediate recall assessments (see C1, P3, C2 and C3) also ranked highest in delayed recall assessments although the individual participants changed position with the exception of C1. Participants who recalled the lower amount of information on immediate recall tasks (see C7, C8 and C9) also recalled the lower amount in delayed recall tasks and participants scoring in-between these scores also had the same level of recall in delayed recall (see C4, C5 and C6).

Table 5.4
Ranking and performance of learning by participants for immediate and delayed recall

Participant ranking and percentage correct for immediate recall		Participant ranking and percentage correct for delayed recall		Participant ranking and percentage of items retained from immediate recall	
C1	**99**	**C1**	**82**	**C1**	**83**
P3	**90**	**C3**	**66**	**C3**	**80**
C2	**89**	**C2**	**59**	C5	**80**
C3	**83**	**P3**	**53**	**C9**	**74**
C4	**67**	C4	**45**	**C7**	**71**
C5	**62**	C5	**50**	C6	**70**
C6	**59**	C6	**41**	C4	**67**
C7	**48**	**C7**	**35**	**C2**	**66**
C8	**48**	**C8**	**32**	**C8**	**66**
C9	**24**	C9	**18**	**P3**	**49**
C10	**16**				
C11	**15**				

However, a different pattern emerged following the analysis of the percentage of information retained from the immediate recall tasks. C1 and C3 who achieved high scores for both immediate and delayed recall tasks retained the most information from initial training sessions. Interestingly C9 and C7 who were ranked as low scorers in the immediate and delayed recall tasks were ranked 4th and 5th respectively in the amount of new learning they retained, indicating that although C9 and C7 had only learned 24% (raw score 76 from a possible maximum of 320) and 48% (raw score of 155 from a possible maximum of 320) (respectively), they retained 74% and 71% of this new learning (respectively), suggesting a deep level of learning or a good ability to recall it from long-term memory. Conversely, P3 and C2 were ranked high scorers in their ability to learn and recall the information about the new words however they only retained 49% and 66% respectively of this newly learned vocabulary. This indicates that perhaps they were able to learn the information initially but it was not all stored in long-term memory or they were unable to retrieve the information they had learned. Therefore, the amount of information learned in the immediate recall did not relate to the percentage of that information retained.

5.3.1 Comparison of characteristics of learning between aphasic and normal populations

The pattern of wide variation in the performance of people with aphasia mirrored that of the normal population performance in the preliminary and pilot studies (see section 3.5 and 4.4). There were also some qualitative similarities between the normal population and the aphasic population. Occasionally, they made semantic errors between the new words and the images; phonemic errors; described skills when unable to think of the target word (e.g. ‘something to do with vision’, for the skill of x-ray vision), and experienced between-session interference when the name (new word) or skill for one creature was attributed to another. However, qualitative differences were also revealed in the data for the population with aphasia when compared with the data from the normal population. Those aspects of performance unique to the participants with aphasia are presented with some examples in Table 5.5 below. It was felt therefore that the variation in performance of people with aphasia could be attributed to more than merely normal variation.

Table 5.5
Characteristics of error types unique to the aphasic participants

Error type	Examples
Within-session interference (mainly perseveration)	* target and response one = HAMEKIN next target – FEETOKEL, response = FEETAKIN * target and response on = [vɪntɹɔk], next target – [zʉdɔp], response = [zʉdɹɔp]
Reading aloud errors (but could spell correctly)	* correct written form LUNDRIL, reading target – [lʌndɹəl], reading response = [lʌndəɹɪŋ] * correct written form ZOODOP, reading target - [zʉdɔp], response = [zʉdɹɔp]
Spelling difficulties (but could say correctly)	* target and correct spoken recall [waŋgɔɹ], written spelling = WANDOR * target and correct spoken recall [fʉtaɹg], written spelling = FURAGE
Semantic errors (familiar word options were fruit, meat, vegetables or meat)	responses included, tomatoes, bananas, cheese and crabmeat.
Phonemic errors (familiar words)	Skills and habitat / food
Lexicalisation of words spoken and reading	* target [pɛntaɹ], response = [pɛntəgɔn] * target [lʌdɹəl], response = [lʌndən] * target [ʃɔɹpaɪn], response = [ʃɔɹlaɪn]
Inability to inhibit words	* target [sneɪtl], response = [sneɪl] * target [fʉtaɹg], response = [fʌtbɔl]

As the population of aphasia is generally agreed to be heterogeneous a case series presenting each individual's ability to learn the new vocabulary as well as individual profiles of participants are presented below to determine whether the factors accounting for the variability in performance could be identified.

5.4 CASE SERIES

This investigation has established that people with post-stroke aphasia can demonstrate the learning of new vocabulary. The variation in learning ability has been highlighted above. The individual profiles of each participant will now be presented, incorporating relevant personal and medical information as well as raw scores on pre-training assessments (see section 4.2). Additionally, each participant's individual ability to learn and retain the new vocabulary is also presented.

5.4.1 Individual profile structure

In order to orientate the reader to the information presented the contents of the following tables will now be explained (see Table 5.6 below for an example).

Table 5.6
Example of participant profile table

Personal details		Language screening scores	Word	N-word
Gender		Listening lexical decision		
Age		Repetition		
Education (yrs)		Reading lexical decision		
Pre-morbid employment -		Read aloud		
Months post-stroke		Spelling		
Stroke details -		Categorisation		
HADs anxiety		Naming		
HADs depression		CLQT language		
Independent learning		Aphasia score		

Cognitive sub-test scores on CLQT					**Stepping-stone Route**
Attention	Memory	Executive function	Visuospatial skills	Clock drawing	Non-linguistic learning

The first column in each table displays participant personal details including gender, age, number of years in education, pre-morbid employment, number of months post-stroke and brief details of their stroke type and location. This column will also present anxiety and depression levels from the HADs self-rating scores (Zigmond and Snaith, 1983) as well as the total time taken by each participant for independent learning during the training procedure (see section 4.3.2.3). The second column presents each person's raw scores for the language screening assessment as described in the previous chapter (see section 4.2.3) and includes the listening and reading lexical decision of words and non-words; repetition of words and non-words; reading aloud and written spelling of words and non-words; categorisation of shapes, pictures and words and the confrontation naming of pictures. The language score sub-test from the CLQT (Helm-Estabrooks, 2001) (see section 4.2.2.1) and the total language screening scores, representing a person's severity of aphasia (see section 4.2.3), are also presented in this column. The remaining individual sub-tests of the CLQT (Helm-Estabrooks, 2001) are presented at the bottom of this table (i.e. attention, memory, executive function, visuospatial skills and clock drawing skills) and an indication of the severity of impairment in each domain is presented (normative scores are presented in Appendix 4.3 for reference). Finally, the immediate and delayed recall scores for the non-linguistic learning task are combined and presented in this table (see section 4.2.2.2).

Qualitative data is also presented and summarised for each participant. This includes a description of each participant's relevant social and medical background. As discussed earlier (see section 4.4.4.2), each participant narrated the Cinderella story in spoken and written formats (where able) to provide qualitative data on participants' connected speech. These narrations are reported in Appendix 5.3a-5.3h. Characteristics of participants' language are summarised using data from the Cinderella narrative and performance on language screening assessments. A representation of each participant's single word processing strengths and difficulties is mapped on to cognitive neuropsychology architectures (see section 2.9.3). The legend for individual module details on the model consists of the following; a plain coloured background (pink for female, lavender for male) indicates no impairment in this module/pathway (i.e. one or no errors) and a patterned highlighted module indicates impairment.

5.4.2 Predictions of influencing factors on learning the new vocabulary

Predictions were made regarding each participant's ability to learn the new vocabulary based on the literature (see section 2.6) and their individual language strengths and difficulties (see section 2.9.3). The literature suggests a number of factors that are considered influential in the recovery of aphasia, which could also affect the ability of individuals to learn the new vocabulary (see section 2.6). Therefore predictions will be made regarding the expected ability of participants in learning the new vocabulary when a number of relevant influencing factors are considered. Some factors will not be considered due to insufficient participant information, in particular, cognitive reserve (see section 2.6.1.3), biological limitations (see section 2.6.2) and the history of aphasia rehabilitation (see section 2.6.4). The various factors that will be considered in light of participants' ability to learn new vocabulary are segmented into a number of categories: personal attributes, cognitive abilities, language abilities and learning strategies and are now discussed.

5.4.2.1 Personal attributes

The personal attributes that were considered for the main investigation included age, education, emotional status and stage of recovery post-stroke and will be discussed below in relation to relevant literature.

Age

Although the evidence in the literature is equivocal for the prognostic effect of age on recovery from aphasia it is considered that overall younger people demonstrate better recovery than older (see section 2.6.1.1). It is therefore expected that younger participants in the main investigation would learn more new vocabulary than older participants.

Education

The evidence in the literature is also equivocal for the influence of education on the recovery of aphasia (see section 2.6.1.2). However, interestingly, Robertson (1999) states that the skills acquired while in education develop the ability to learn i.e. a person learns how to learn, developing skills such as planning, memorising and problem solving. Previous research studies do not state the required number of years in education to promote these skills therefore it could only generally predict that participants with more years in education would learn more than those with less educational experience. The skills required for the employment of each participant will also be commented on in consideration of their ability to learn new vocabulary.

Emotional status

The effect of emotional status of individuals is less ambiguous, suggesting that both anxiety and depression influence the motivation of participants as well as their cognitive and linguistic performance (see section 2.6.3.2), predicting that those participants who experience emotional difficulties would experience a negative influence on the learning of new vocabulary.

Stage of recovery from stroke

As previously discussed (see section 2.2.1), the path of recovery from aphasia is considered to encompass acute stages of recovery where some function is restored due to the restoration of blood flow to neural tissue and the reduction of swelling. The brain then begins to reorganise and reconnect areas of the brain through new neural pathways. Some literature suggests that the chronic stages of recovery involve the acquisition of compensatory techniques rather than restoration of communicative function (see section 2.2.1). However, a small number of studies have provided evidence for cortical plasticity in the language areas of the brain during the chronic stages of stroke (see section 2.5.5). Information regarding the ability to learn new vocabulary in both the acute and chronic stages of aphasia would be informative to the theory of rehabilitation. The number of months post-stroke was used to denote the recovery stage for each participant. It would be predicted that the brain would be more stable in the chronic stages of recovery and have the capacity for cortical plasticity therefore it would be predicted that the longer post-stroke participants are, the more new vocabulary they would learn.

5.4.2.2 Cognitive abilities and the capacity to learn

The cognitive abilities that were considered for the main investigation were assessed using the CLQT (see section 4.2.2.1) and included attention, memory, executive function and clock drawing skills. Visuospatial skills were observed to ensure there were no difficulties with task materials. The presence of cognitive impairment is considered to be an influencing factor on recovery and is thought to be involved in the acquisition and management of knowledge (see section 2.6.3.3), therefore it would be predicted that participants with cognitive difficulties would learn less new vocabulary than those without any impairment. Another factor that would be predicted to influence participant learning of the new vocabulary is the ability of participants to demonstrate the cognitive capacity to learn. If a person could not demonstrate the general capacity to learn, they would not be expected to be able to learn domain specific information such as language. Therefore, for those participants in this investigation who were unable to demonstrate the capacity to learn the non-linguistic stepping-stone route it was predicted that they would also not be able to demonstrate the learning of the new vocabulary.

5.4.2.3 Severity of aphasia

While the initial severity of aphasia experienced by participants was also not known (see section 2.6.3.1), it was decided to consider the potential for learning the new vocabulary in respect of current severity of aphasia as determined by total scores from the language screening assessments (see section 4.2.3). Each language screening assessment result was depicted on a cognitive neuropsychology model in terms of the various modules and pathways utilised for each task, highlighting each participant's strengths and difficulties in their single word processing abilities. This was used to predict individual ability to learn the word forms and meanings of the new vocabulary both in spoken and written form. The language sub-section of the CLQT was also considered in noting the severity of aphasia.

5.4.2.4 Rehearsal and consolidation of learning

The importance of rehearsal in the acquisition of knowledge has been discussed. Mental rehearsal has been demonstrated to invoke neuronal activity changes and foster synaptic connections between neurones and is considered fundamental in transferring knowledge from short-term memory to long-term memory (see section 2.5.2). The independent learning time of 30 minutes was incorporated into each training session (see section 3.7 and 4.3.2.3), however participants were not required to use the full 30 minutes. It would be predicted that participants who employed all 30 minutes independent learning time to rehearse and consolidate the new vocabulary would learn more vocabulary than participants who did not.

A participant's ability to demonstrate the learning of the new vocabulary is presented individually providing both quantitative and qualitative information about their particular language characteristics. An evaluation of the predictions is discussed in the final chapter (see section 6.5.4). The summary of each individual's results refers to the cold recall tasks both spoken and written form in the first instance (see section Figure 5i). If a person was unable to demonstrate their full ability from these tasks, performance on other assessments is summarised. Each assessment task has a highest maximum total of 20. A case series of all 12 participant profiles and performance scores is now presented. Table 5.7 below presents a combined glossary and legend to facilitate further interpretation of the tables and summaries in the case series. For ease of reference P3 (pilot study) continues to be labelled as P3 and all other main investigation participants are labelled from C1 to C11 (with C1 having the highest score and C11 the lowest).

Table 5.7
Glossary and legend for following case series tables

Participant coding The following coding of participants enables as much information to be given for each case study while maintaining participant confidentiality.	
P3	Participant from pilot number three (see section 4.6)
C1	This represents case study one
C2, C3	These represents case study two, three, etc.
Tables presenting learning performance of new vocabulary	
IR	Immediate recall assessment - immediately following the independent learning time
DR	Delayed recall assessment – 3-5 days after final training session
(S)	Participant to give response in spoken form
(L)	Participants listen to tasks either pre-recorded or live
(R)	Participants read tasks
(W)	Participants give written responses
(P)	Participants categorise using pictures of creatures
N-word	Non-word
(CR)	Cold recall – where information about each creature (name, skill, habitat and food) is required from participants looking solely at a picture of each creature
Cognitive Neuropsychology Model summary descriptors	
APA	Auditory Phonological Analyses
PIL	Phonological Input Lexicon
APC	Acoustic to Phonological Conversion
POL	Phonological Output Lexicon
POB	Phonological Output Buffer
VOR	Visual Object Recognition
SS	Semantic system
ALI	Abstract Letter Identification
OIL	Orthographic Input Lexicon
OOL	Orthographic Output Lexicon
LPC	Letter to Phonological Conversion
PLC	Phonological to Letter Conversion
GOB	Graphemic Output Buffer

5.5 PARTICIPANT C1

Participant C1's personal profile is presented in Table 5.8. C1 had moderate right-sided residual paresis and lived alone independently. Since her stroke she had been actively involved in a charity for young post-stroke people. She also recently completed a college course to help improve writing and office skills and had returned to work with reduced responsibilities. C1 was discharged from speech and language therapy at the time of the investigation.

Table 5.8
C1's personal, medical, language and cognitive data

Personal details		Language screening scores	Word	N-word	
Gender	F	Listening lexical decision	8	8	
Age	39;05	Repetition	8	6	
Education (yrs)	21.5	Reading lexical decision	8	8	
Pre-morbid employment – Trading Standards Officer		Read aloud	7	5	
Months post-stroke	66	Spelling	6	3	
Stroke details – Left middle and anterior infarct		Categorisation	15	15	15
HADs anxiety	6	Naming	12		
HADs depression	4	CLQT language	30	WNL	
Independent learning	120mins	Aphasia score	124	93.2%	

Cognitive sub-test scores on CLQT					**Stepping-stone Route**
Attention	Memory	Executive function	Visuospatial skills	Clock drawing	Non-linguistic learning
203	163	30	99	12	18
WNL	WNL	WNL	WNL	WNL	100%

5.5.1 Predictive factors for learning new vocabulary

The various factors for determining predictors of new learning are discussed in section 5.4.2 and are evaluated below for C1 with reference to the data in Table 5.8.

5.5.1.1 Personal attributes

C1 was aged 39.05 at the time of the investigation and was one of the youngest participants. It would therefore be predicted that C1 would learn more new vocabulary than older participants. C1 had spent 21.5 years in education and would be expected to have highly developed skills in learning (see section 2.6.1.2). Employed as a Trading Standards Officer, C1 would have used skills in being attentive to detail, absorbing complex information and have good communication skills (www.learndirect-advice.co.uk - profile 209). C1's self-rating for anxiety and depression placed her within normal limits and she was 66 months post-stroke. It would be predicted that C1's personal attributes would contribute favourably in learning the new vocabulary.

5.5.1.2 Cognitive abilities and the capacity to learn

The sub-tests of CLQT indicate that C1's cognitive abilities were considered to be within normal limits. She demonstrated the capacity to learn new information by achieving 100% for the immediate and delayed recall of the non-linguistic task. It was therefore predicted that cognitive abilities would enhance the ability of C1 to learn the new vocabulary in particular intact attention and memory.

5.5.1.3 Severity of aphasia

The language sub-test of the CLQT indicated that C1's language abilities were within normal limits. Her language screening scores are displayed in Table 5.8 for each task and mapped on to a cognitive neuropsychology model in Figure 5ii below. C1's language data indicated that she had difficulties in repeating, reading aloud and spelling non-words (suggesting impairments in LPC, APC, PLC, POB and GOB pathways). While the data indicates that C1 could name, read, repeat and spell single words, qualitative data revealed that her connected speech was hesitant and contained many fillers (e.g. um, eh) and pauses that disturbed the flow of her speech (see narration of the Cinderella story in Appendix 5.3a).

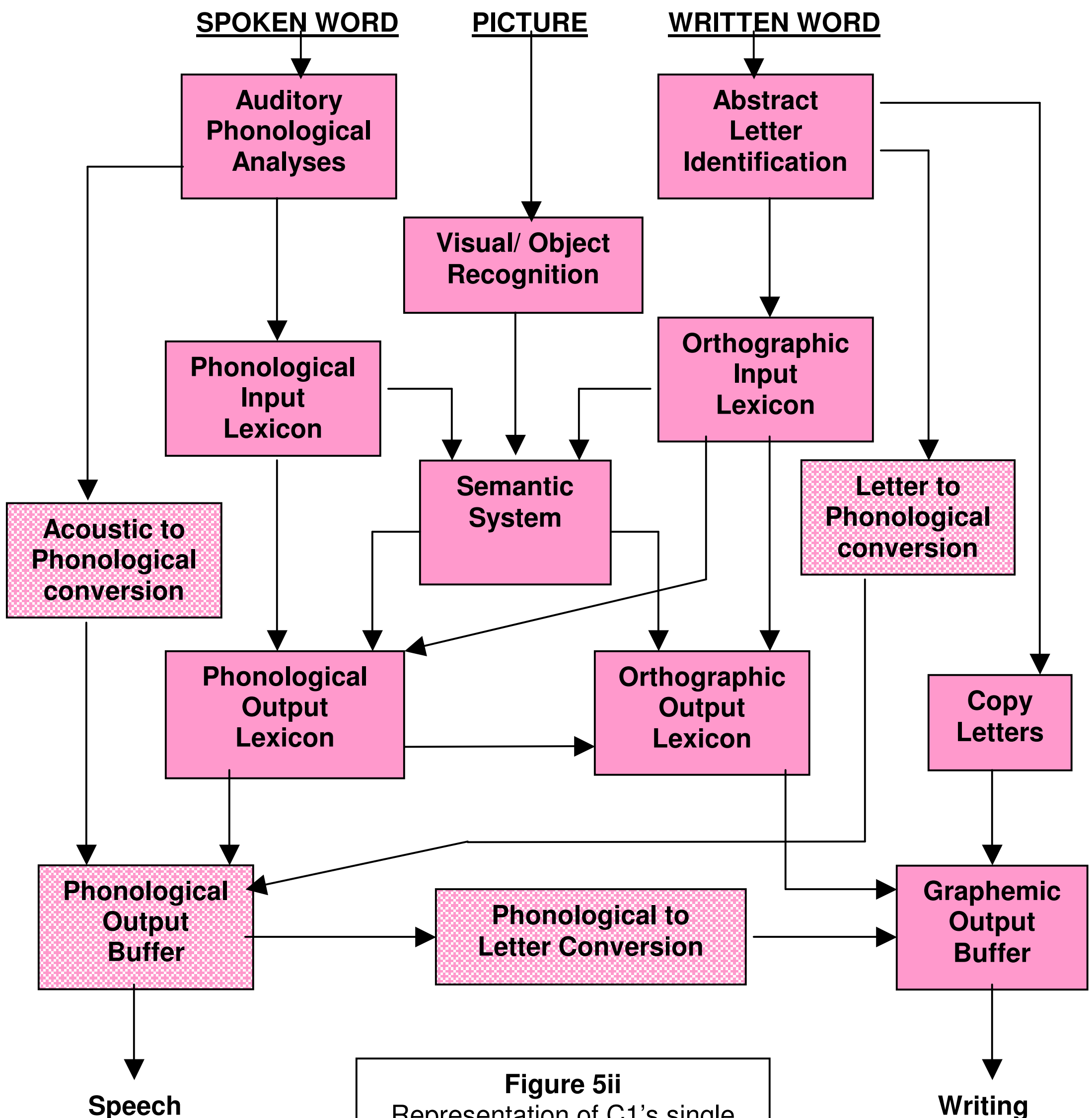


Figure 5ii
Representation of C1's single word processing abilities

C1 characteristically practised and repeated many words under her breath before speaking them aloud and tended to make phonemic errors although these were quickly and accurately self-corrected. At single word level (see Table 5.8 and Figure 5ii) it was predicted that C1 would be able to learn the word forms and word meanings of the new vocabulary but would make articulation errors when repeating and reading aloud and spelling errors when spelling the new words. Qualitative data suggests that C1 may characteristically make phonemic errors but self-correct articulation errors accurately.

5.5.1.4 Rehearsal and consolidation of learning

C1 used the full 30 minutes of independent learning time to rehearse the new vocabulary. During this time she completed practise assessments and played the audio recording a number of times. She also practised writing the details of each creature and could be heard practising under her breath.

5.5.2 Demonstration of learning the new vocabulary

C1's performance on each assessment task is presented in Table 5.9 below and her ability to learn the new vocabulary is summarised for both immediate and delayed recall assessments.

5.5.2.1 Immediate recall

Table 5.9
C1's detailed performance on learning new vocabulary

Assessment (type)	Raw score		Assessment (type)	Raw score	
	IR	DR		IR	DR
CR – NAME (S)	20	14	Read aloud (R)	19	20
CR – NAME (W)	20	14	W-P match – NAME (L)	20	20
CR – SKILL (S/W)	19	12.5	W-P match – NAME (R)	20	20
CR – HABITAT (S/W)	20	13	W-P match – SKILL (L)	20	20
CR – FOOD (S/W)	20	13	W-P match – SKILL (R)	20	20
Recognition (L)	20	20	Categorisation– HABITAT/FOOD (P)	20	12
Recognition (R)	20	20	Categorisation– HABITAT/FOOD (R)	20	6
P-S match (P)	20	19			
Syllable completion (R)	20	20	**TOTAL SCORE**	**318**	**263.5**

C1 recalled all 20 of the new words in spoken form and did not require any cues to aid recall (see Table 5.9). She made five phonemic errors for spoken recall (e.g. fʉta˩˥d instead of fʉta˩˥g; fitʌkam instead of fitʌkɛl) and there were very long pauses between her responses. C1 also made phonemic errors on already familiar words (e.g. kakʌs instead of kaktʌs). C1 also recalled all 20 words in written form again without the aid of cues and made three spelling errors (e.g. FEETOKIN instead of FEETOKEL and VINTROP instead of VINTROK).

5.5.2.2 Delayed recall

As presented in Table 5.9, C1 recalled 14 of the newly learned words in spoken form requiring two phonemic and 11 syllable cues to aid recall. Six of these cues were successful. C1 also recalled 14 of these words in written form where she repeated the words / syllables under her breath a number of times to facilitate the spelling of words. C1 could however accurately match all 20 creature names and skills to their images (listening and reading) and completed all 20 syllables, indicating that she had in fact learned all 20 creatures but required more information to aid recall for some words. In the assessment sessions C1 demonstrated word-finding difficulties in particular for the already familiar words of the creature skills and used other words to describe some of them (e.g. 'reads minds' for 'telepathic', 'whirling up storms' for 'creates storms').

5.5.2.3 Summary of new learning

As predicted, C1 demonstrated the learning of the vocabulary achieving 99% of information correct for immediate recall assessments. She demonstrated long-term retention of this learning recalling 82% for delayed recall tasks, remembering 83% of information originally recalled. C1 had demonstrated difficulty spelling non-words in baseline measures, for example, target – NAR, response = NRVN, target – SMODE, response = SMEI. Although predicted that C1 would have difficulty spelling non-words only 15% of written naming contained errors and these were closer to target words than non-word errors at baseline, for example, target FEETOKEL, response = FEETOKIN, target – VINTROK, response = VINTROP. This suggests that some of these new words were now stored as 'familiar' words in her lexicon.

5.6 PARTICIPANT P3

As participant P3 was included in the pilot studies his personal profile was presented in section 4.6.1 and also in Table 5.10 below.

Table 5.10
P3's personal, medical, language and cognitive data

Personal details		Language screening scores	Word		N-word
Gender	M	Listening lexical decision	8		8
Age	64;04	Repetition	8		8
Education (yrs)	20	Reading lexical decision	8		8
Pre-morbid employment - Pharmacist		Read aloud	7		4
Months post-stroke	7	Spelling	6		3.5
Stroke details – Left fronto parietal infarct		Categorisation	15	15	14
HADs anxiety	1	Naming	12		
HADs depression	1	CLQT language	26		Mild
Independent learning	120mins	Aphasia score	124.5		93.6%

Cognitive sub-test scores on CLQT					**Stepping-stone Route**
Attention	Memory	Executive function	Visuospatial skills	Clock drawing	Non-linguistic learning
144	149	21	78	13	18
Mild	Mild	Mild	Mild	WNL	100%

5.6.1 Predictive factors for learning new vocabulary

The various factors for determining predictors of new learning are discussed in section 5.4.2 and are evaluated below for P3 with reference to the data in Table 5.10.

5.6.1.1 Personal attributes

P3 was aged 64.04 at the time of the investigation and was one of the oldest participants. It would therefore be predicted that P3 would learn less new vocabulary than younger participants. However, P3 had experienced 20 years of formal education and had completed undergraduate and post-graduate degrees (see section 4.6.1), and therefore would be expected to have highly developed skills in learning (see section 2.6.1.2). P3's employment as a pharmacist involved specialist training and having excellent organisation skills, being able to work methodically, have logical thought processes and highly developed communication skills (www.learndirect-advice.co.uk - profile 163). P3's self-rating for anxiety and depression placed him within normal limits and he was seven months post-stroke. Despite P3's age it would be predicted that his experience in education and employment would have a positive impact on his ability to learn new vocabulary. Additionally, there were no adverse emotional factors to impact upon his learning ability.

5.6.1.2 Cognitive abilities and the capacity to learn

The CLQT indicated that P3 had mild cognitive difficulties in attention, memory, executive function and visuospatial skill domains. Clock drawing skills were within normal limits. P3 demonstrated adequate attention, memory and executive function skills to achieve 100% accuracy in learning the non-linguistic task for both immediate and delayed recall. His ability to copy words and draw the creature images in detail demonstrated that any visuospatial difficulties did not affect the tasks involved in the investigation. As P3's cognitive difficulties were mild in nature and he had demonstrated the capacity to learn new information it was predicted that cognitive factors would not severely impact upon his learning of the new vocabulary.

5.6.1.3 Severity of aphasia

The language sub-test of the CLQT indicated that P3 had mild language difficulties. Language screening scores for P3 are displayed in Table 5.10 for each task and mapped on to a cognitive neuropsychology model in Figure 5iii below.

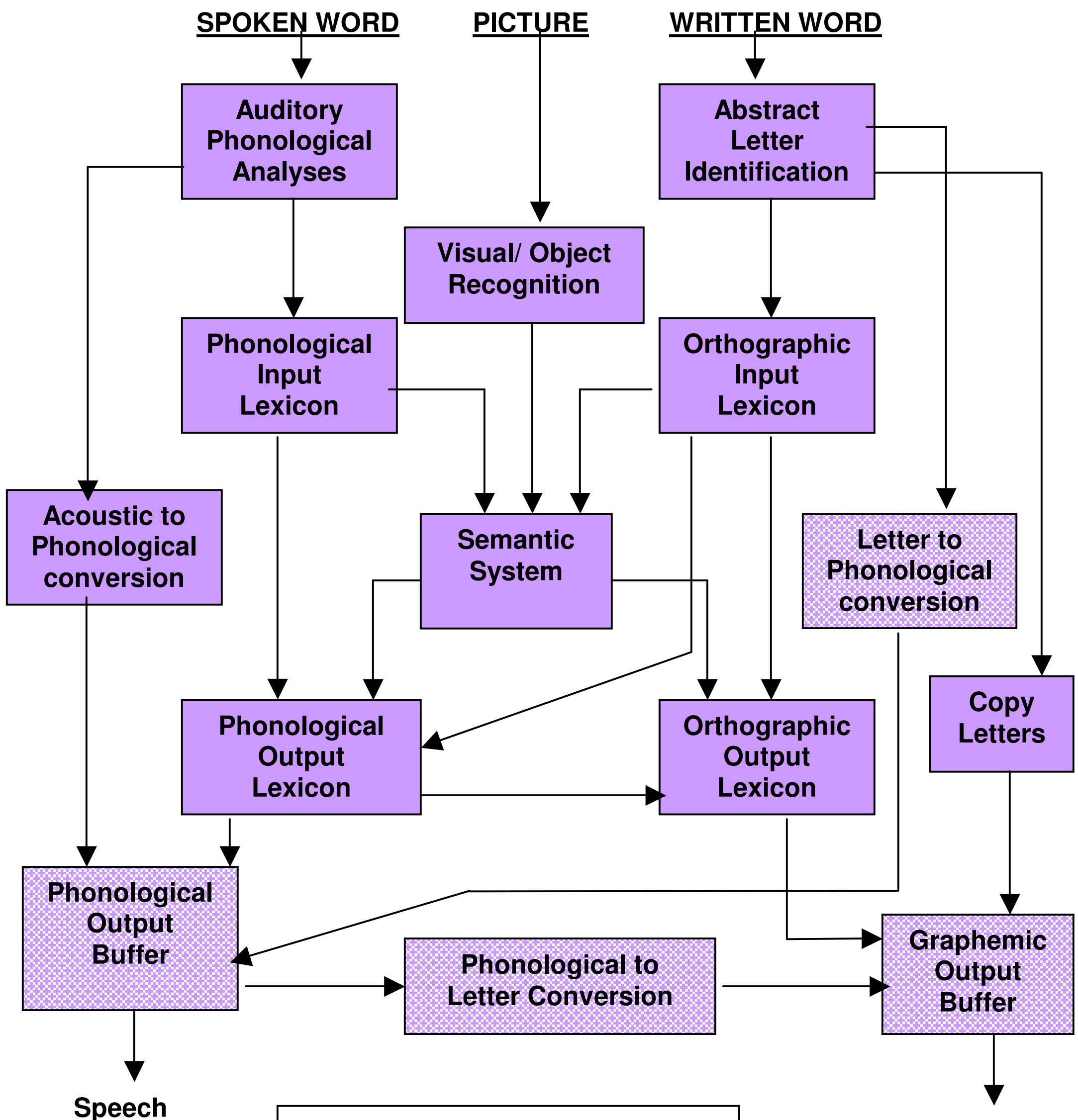


Figure 5iii
Representation of P3's single word processing abilities

For single words P3 demonstrated that he could recognise and repeat both words and non-words accurately and had no difficulties naming pictures. He found reading aloud and spelling non-words difficult (suggesting an impairment in LPC, POB, PLC and GOB pathways) (see Figure 5iii). While quantitative data (see Table 5.10) indicated P3's ability to name, read and spell single words accurately, qualitative data revealed that in conversation his connected speech was non-fluent with many repetitions and re-starts of initial phonemes, syllables and some phrases. Perseveration was also notable (see narrative of Cinderella story in Appendix 5.3b). P3 was consistently aware of his errors and attempted immediate self-correction, becoming increasingly frustrated when unable to achieve a target word. At single word level (see Table 5.10 and Figure 5iii) it was predicted that P3 would be able to learn the word forms and word meanings of the new vocabulary but would make some articulation errors when reading aloud and spelling errors when writing the new words. Qualitative data suggested that perseveration might be a feature of new learning for P3.

5.6.1.4 Rehearsal and consolidation of learning

P3 used the full 30 minutes of independent learning time to rehearse the new vocabulary. During this time he studied the practise assessments without physically completing them. He wrote the skills (or their initials) next to the pictures and names that he had drawn as part of the training tasks, for sessions one to three and utilised the audio pre-recordings for session four.

5.6.2 Demonstration of learning the new vocabulary

P3 had a very rushed approach to all training and recall tasks. His performance on each assessment task is presented in Table 5.11 below and his ability to learn the new vocabulary is summarised for both immediate and delayed recall assessments.

5.6.2.1 Immediate recall

P3 was able to recall 18 of the 20 new words in spoken form requiring four syllable cues to aid recall. As predicted, perseveration appeared to interfere in his ability to recall the other two words in spoken form being unable to inhibit the perseveration of phonemes from the previous word, (e.g. target ‘kʌɹvɔl’, response wɔntɔɹ which followed the word waŋgɔɹ). Of the 18 correct words 40%

had articulation errors. P3 also recalled 19 of the new words in written form, requiring only one letter cue.

Table 5.11
P3's detailed performance on learning new vocabulary

Assessment (type)	Raw score		Assessment (type)	Raw score	
	IR	**DR**		**IR**	**DR**
CR – NAME (S)	**18**	**3 / 12**	Read aloud (R)		**17**
CR – NAME (W)	**19**	**11**	W-P match – NAME (L)	**20**	**14**
CR – SKILL **(S/W)**	**9**	**0**	W-P match – NAME (R)	**20**	**16**
CR – HABITAT **(S/W)**	**20**	**0**	W-P match – SKILL (L)	**18**	**10**
CR – FOOD **(S/W)**	**20**	**0**	W-P match – SKILL (R)	**20**	**8**
Recognition (L)	**20**	**20**	Categorisation– HABITAT/FOOD (P)	**18**	**5**
Recognition (R)	**20**	**19**	Categorisation– HABITAT/FOOD (R)	**15**	**4**
P-S match (P)		**16**			
Syllable completion (R)	**16**	**17**	**TOTAL SCORE**	**253**	**160/ 169**

5.6.2.2 Delayed recall

As can be seen on Table 5.11, P3 initially only recalled three of the 20 newly learned words in spoken form during the delayed cold recall tasks despite receiving 19 syllable cues. However, while performing the habitat and food picture categorisation task he began to name the creatures spontaneously retrieving 12 of these 20 correctly. He was given 16 cues in total to aid retrieval. P3 recalled 11 of the new words in written form. P3 could however accurately match 14 (listening) and 16 (reading) creature names to their images indicating that he had learned more characteristics of the new words than demonstrated through naming tasks alone but required additional information about the new words to aid recall for some of the new vocabulary.

5.6.2.3 Summary of new learning

As predicted P3 was able to demonstrate the learning of new word forms and meanings achieving 90% of information correct for immediate recall assessments. He demonstrated that some of this information was retained in long-term memory as he recalled 53% of information for delayed recall tasks, remembering 49% of information originally recalled. P3 had demonstrated difficulty spelling non-words in baseline measures, for example, target – TROKE, response = TRUCTHRO, target – CHURSE, response = CHYRCH. Although predicted that he would have difficulty spelling non-words (see Table 5.10) only 25% of his written naming of the new words had spelling errors and these errors were closer to the target words than baseline measure attempts at spelling non-words, for example, target – PONCHINO, response = PUNCHINO, target – WANGOR, response = WANDOR. This suggests that many of these new words were now stored as 'familiar' words in his lexicon. As expected P3's age or mild cognitive impairment did not appear to have major impact upon his learning.

5.7 PARTICIPANT C2

Participant C2's profile is displayed in Table 5.12. He lived with his wife and, despite severe hemiparesis on his right dominant side (upper limb), was fully mobile and independent. C2 was actively involved in a charity for post-stroke people and had an active social life. C2 was receiving weekly individual and group speech and language therapy at the time of the investigation.

Table 5.12
C2's personal, medical, language and cognitive data

Personal details	
Gender	M
Age	33;11
Education (yrs)	17
Pre-morbid employment - Engineer	
Months post-stroke	39
Stroke details – Left middle cerebral infarct	
HADs anxiety	4
HADs depression	4
Independent learning	120mins

<table>
<tr><th>Language screening scores</th><th colspan="2">Word</th><th colspan="2">N-word</th></tr>
<tr><td>Listening lexical decision</td><td colspan="2">8</td><td colspan="2">6</td></tr>
<tr><td>Repetition</td><td colspan="2">7</td><td colspan="2">3</td></tr>
<tr><td>Reading lexical decision</td><td colspan="2">8</td><td colspan="2">6</td></tr>
<tr><td>Read aloud</td><td colspan="2">2</td><td colspan="2">0</td></tr>
<tr><td>Spelling</td><td colspan="2">6</td><td colspan="2">2</td></tr>
<tr><td>Categorisation</td><td>15</td><td colspan="2">15</td><td>15</td></tr>
<tr><td>Naming</td><td colspan="4">6.5</td></tr>
<tr><td>CLQT language</td><td colspan="2">17.5</td><td colspan="2">Severe</td></tr>
<tr><td>Aphasia score</td><td colspan="2">99.5</td><td colspan="2">74.8%</td></tr>
</table>

Cognitive sub-test scores on CLQT					**Stepping-stone Route**
Attention	Memory	Executive function	Visuospatial skills	Clock drawing	Non-linguistic learning
197	129	30	103	13	18
WNL	Moderate	WNL	WNL	WNL	100%

5.7.1 Predictive factors for learning new vocabulary

The various factors for determining predictors of new learning are discussed in section 5.4.2 and are evaluated below for C2 with reference to the data in Table 5.12.

5.7.1.1 Personal attributes

C2 was aged 33.11 at the time of the investigation and was the youngest participant. It would therefore be predicted that C2 would learn more vocabulary than older participants. C2 had experienced 17 years in education and would be expected to have developed learning skills. He was employed in a highly specialised job, which required the development of analytical skills and the ability to critically evaluate complex problems and solutions as well as excellent communication skills (www.learndirect-advice.co.uk - profile 357). C2's self-rating for anxiety and depression was considered to be within normal limits and he was 39 months post-stroke. It was predicted that C2's personal attributes would contribute favourably to the learning of new vocabulary.

5.7.1.2 Cognitive abilities and the capacity to learn

The cognitive sub-tests of the CLQT indicated that C2's cognitive abilities were within normal limits with the exception of memory (moderately impaired). Such impairment would predict a difficulty learning and recalling the new vocabulary (see section 2.6.3.3). However, it was felt that the CLQT score did not give an accurate reflection of C2's memory. Firstly, the CLQT only accepted spoken responses – C2 gave accurate gesture and written responses to the tasks (being unable to do so in spoken form – see section 5.7.1.3). Secondly, he demonstrated the capacity to recall newly learned information by recalling 100% of the non-linguistic task for both immediate and delayed recall. These issues will be addressed in the discussion chapter.

5.7.1.3 Severity of aphasia

The language sub-test of the CLQT suggested that C2 had severe language difficulties. His language screening scores are displayed in Table 5.12 for each task and mapped on to a cognitive neuropsychology model in Figure 5iv below.

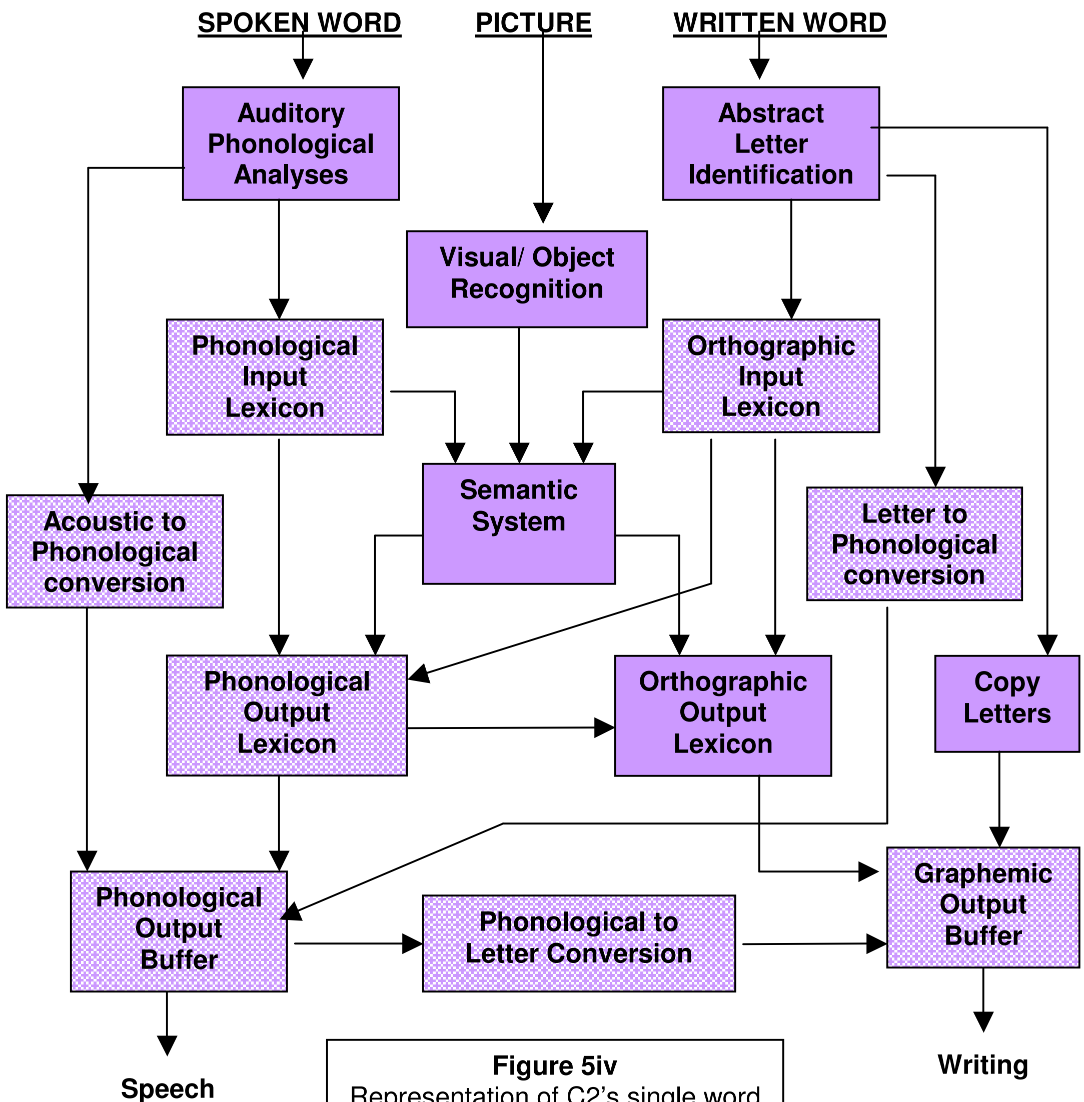


Figure 5iv
Representation of C2's single word processing abilities

C2's data (see Table 5.12 and Figure 5iv above) indicated that he had a number of language difficulties at single word level. C2's ability to categorise pictures and words suggested that he could adequately access his semantic system. He could also write real words correctly. However, C2 had some difficulty differentiating real from non-words (suggesting impairment to PIL and OIL). Significantly, he demonstrated severe impairment with all spoken output, i.e. repetition, reading aloud, spoken naming and also had difficulties spelling non-words (suggesting impairment to PIL, APC, POL, POB and OIL, LPC, PLC and

GOB pathways). C2's speech was characteristic of spoken dyspraxia where he groped for the target sound and frequently self-corrected in an attempt to achieve the correct word. On most occasions C2 did not achieve the target words. His low score in naming pictures appeared to be exacerbated by dyspraxic speech where he could retrieve the words from his semantic system but had difficulties articulating the words accurately. Although he found this frustrating he used writing single words and drawing successfully to effectively communicate his message. C2 was unable to narrate the Cinderella story either in spoken or written formats. It was predicted that C2 would be unable to demonstrate the learning of the new vocabulary in spoken form but would rely on evidencing this learning through drawing and writing. It was also expected that C2 would have difficulty spelling the new word forms unless they became registered as real words in his lexicon.

5.7.1.4 Rehearsal and consolidation of learning

C2 rehearsed the new vocabulary for the full 30 minutes of independent learning time for all training sessions. During this time he practised the completion of the assessments, listened to the audio recording and wrote down the creature details a number of times for each session.

5.7.2 Demonstration of learning the new vocabulary

C2's performance on each assessment task is presented in Table 5.13 below with a summary of his ability to learn the new vocabulary for both immediate and delayed recall assessments.

5.7.2.1 Immediate recall

C2 recalled four of the new words in spoken form requiring two phonemic and six syllable cues to aid recall. Three of these words contained phonemic errors (e.g. target pɔpkɪnɛl, response pɔpkɪŋaɪ; target jamtɔɹk, response jamtɔɹ).

However, C2 demonstrated that he had learned all 20 words as he achieved 100% in the written recall task.

Table 5.13
C2's detailed performance on learning new vocabulary

Assessment (type)	Raw score	
	IR	DR
CR – NAME (S)	4	3
CR – NAME (W)	20	4
CR – SKILL (S/W)	18	0
CR – HABITAT (S/W)	20	12
CR – FOOD (S/W)	20	12
Recognition (L)	18	20
Recognition (R)	20	20
P-S match (P)	20	16
Syllable completion (R)	20	19

Assessment (type)	Raw score	
	IR	DR
Read aloud (R)	5	2
W-P match – NAME (L)	20	19
W-P match – NAME (R)	20	20
W-P match – SKILL (L)	20	9
W-P match – SKILL (R)	20	11
Categorisation–HABITAT/FOOD (P)	20	10
Categorisation–HABITAT/FOOD (R)	19	11
TOTAL SCORE	284	188

5.7.2.2 Delayed recall

As presented in Table 5.13, C2 recalled three of the newly learned words in spoken form (two of these had not been recalled in spoken form in immediate recall assessments) and two of these had phonemic errors. He also recalled four of the new words in written form. However, C2 was able to match the initial syllables of 19 words with their final syllable indicating that he still retained the word form knowledge but required additional information about the new words to aid recall. He also matched 19 creatures to their names for the listening word-picture matching task and 20 creatures for the reading form of this task. The results indicated that although C2 required additional information to retrieve the new word forms and meanings he had retained knowledge of the new vocabulary that he had originally learned.

5.7.2.3 Summary of new learning

C2 demonstrated learning of the new vocabulary by recalling 89% of new information for the immediate recall assessment tasks. He demonstrated long-term retention of this information recalling 59% of information in delayed recall assessment tasks (see Table 5.2), which equated to remembering 66% of information originally learned during the training sessions. As predicted C2 had significant difficulty recalling the new words in spoken form due to his marked dyspraxia and used non-verbal methods to communicate his knowledge of the new vocabulary. Although it was predicted that C2 would have difficulty spelling the new words (as he was only able to spell two of the six baseline non-words), he had no spelling errors when recalling all 20 new words strongly suggesting that this novel vocabulary were now stored as real words.

5.8 PARTICIPANT C3

Participant C3's personal details are presented in Table 5.14. C3 had a history of vascular disease from an early age and presented with severe right upper and lower limb hemiparesis. She mobilised with an electronic wheelchair and her husband's assistance. She mainly stayed in her home enjoying television programmes and occasional day trips with her husband. She was not receiving speech and language therapy at the time of the investigation.

Table 5.14
C3's personal, medical, language and cognitive data

<table>
<tr><th colspan="2">Personal details</th><th>Language screening scores</th><th colspan="3">Word</th><th colspan="3">N-word</th></tr>
<tr><td>Gender</td><td>F</td><td>Listening lexical decision</td><td colspan="3">8</td><td colspan="3">8</td></tr>
<tr><td>Age</td><td>54;03</td><td>Repetition</td><td colspan="3">8</td><td colspan="3">8</td></tr>
<tr><td>Education (yrs)</td><td>13</td><td>Reading lexical decision</td><td colspan="3">8</td><td colspan="3">8</td></tr>
<tr><td colspan="2"><u>Pre-morbid employment</u> - Homemaker</td><td>Read aloud</td><td colspan="3">8</td><td colspan="3">5</td></tr>
<tr><td>Months post-stroke</td><td>96</td><td>Spelling</td><td colspan="3">6</td><td colspan="3">1.5</td></tr>
<tr><td colspan="2"><u>Stroke details</u> - Left parietal extension</td><td>Categorisation</td><td colspan="2">15</td><td colspan="2">14</td><td colspan="2">15</td></tr>
<tr><td>HADs anxiety</td><td>10</td><td>Naming</td><td colspan="6">12</td></tr>
<tr><td>HADs depression</td><td>1</td><td>CLQT language</td><td colspan="3">25</td><td colspan="3">Mild</td></tr>
<tr><td>Independent learning</td><td>120mins</td><td>Aphasia score</td><td colspan="3">124.5</td><td colspan="3">93.6%</td></tr>
</table>

<table>
<tr><th colspan="5">Cognitive scores on CLQT</th><th>Stepping-stone Route</th></tr>
<tr><td>Attention</td><td>Memory</td><td>Executive function</td><td>Visuospatial skills</td><td>Clock drawing</td><td>Non-linguistic learning</td></tr>
<tr><td>185</td><td>133</td><td>24</td><td>88</td><td>13</td><td>18</td></tr>
<tr><td>WNL</td><td>Moderate</td><td>WNL</td><td>WNL</td><td>WNL</td><td>100%</td></tr>
</table>

5.8.1 Predictive factors for learning new vocabulary

The various factors for determining predictors of new learning are discussed in section 5.4.2 and are evaluated below for C3 with reference to the data in Table 5.14.

5.8.1.1 Personal attributes

C3 was aged 54.03 at the time of the investigation and was one of the older participants. It would therefore be predicted that C3 would learn less vocabulary than younger participants but more than older participants. C3 had spent 13 years in education and pre-morbidly was a homemaker. Although homemaking and motherhood requires many organisational and planning skills (http://www.stepfour.com/jobs/301474010.htm) it would be predicted that participants with more education and more highly specialised employment might learn more vocabulary than C3. C3 self-rating for anxiety was quite high with depression rating considered to be within normal limits. She was 96 months post-stroke. Being one of the older participants and having less education and involvement in skilled employment would predict that C3 may not learn as many new words as other more highly skilled and younger participants.

5.8.1.2 Cognitive abilities and the capacity to learn

The cognitive sub-tests of the CLQT indicated that C3's cognitive abilities were within normal limits with the exception of memory, which was moderately impaired. It was felt that this was reflective of C3's word-finding difficulties in the story-retelling task and word generation tasks. Memory impairment would predict some difficulty learning and recalling the new vocabulary (see section 2.6.3.3) however, she demonstrated the capacity to recall newly learned information by recalling 100% of the non-linguistic task for both immediate and delayed recall.

5.8.1.3 Severity of aphasia

The language sub-test of the CLQT suggested that C3 had mild language difficulties. Her language screening scores are displayed in Table 5.14 for each task and mapped on to a cognitive neuropsychology model in Figure 5v below. C3's data (see Table 5.14 and Figure 5v below) indicated that her main difficulty lay in reading aloud and spelling non-words (suggesting impairment to LPC, POB and PLC pathways).

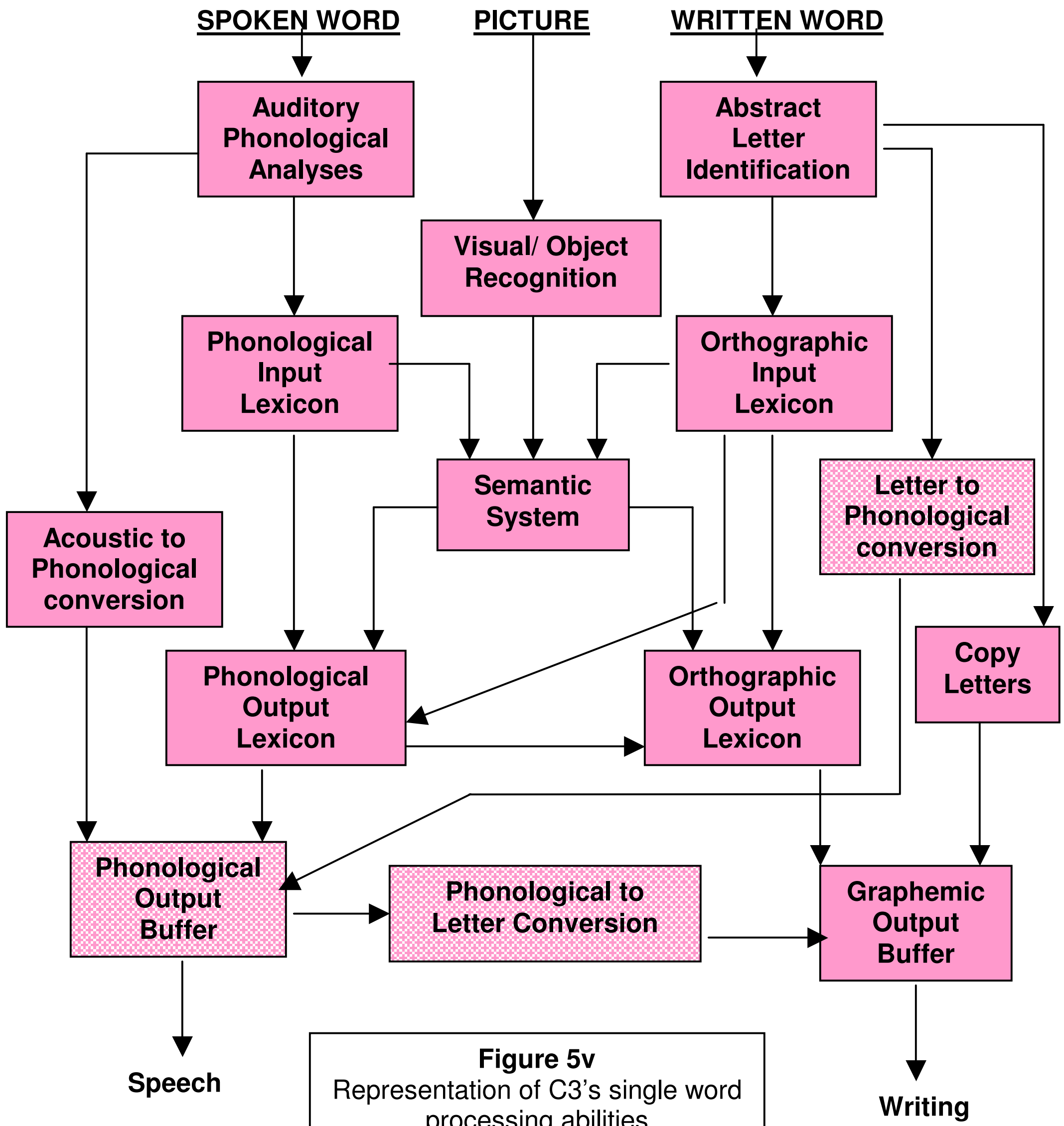


Figure 5v
Representation of C3's single word processing abilities

Qualitatively, C3's speech had a mild dysarthric quality to it and she repeatedly practised target responses under her breath before speaking them aloud sometimes having to restart words a number of times. C3 was aware when she made errors and self-corrected, often succeeding after a number of attempts.

C3’s narration of the Cinderella story is presented in Appendix 5.3c. It was predicted that C3 would be able to demonstrate learning of the new vocabulary successfully in spoken form but may have difficulty reading aloud and spelling the new word forms unless they became registered as real words in her lexicon.

5.8.1.4 Rehearsal and consolidation of learning

C2 utilised the full 30 minutes of independent learning time for all training sessions to rehearse the new words. During this time she practised saying the details under her breath, wrote down the creature details and listened to the audio recording a number of times for each session.

5.8.2 Demonstration of learning the new vocabulary

C3’s performance on each assessment task is presented in Table 5.15 below with a summary of her ability to learn the new vocabulary for both immediate and delayed recall assessments.

5.8.2.1 Immediate recall

C3 recalled 18 of the new words in spoken form requiring three phonemic and two syllable cues and made nine phonological errors (e.g. target lʌndɹəl response lʌndəl; target zʉdɔp response zʉdɹɔp). There was within-session interference from newly learned words (perseveration) as follows. Session one – target and response one = FUTARG; target two - SHORPINE, response = PENTAG; target three - DREEPLE, response = PENTAN; target four - PENTAR, response = PENTAN; target five - SARTLE, response = STARTLE; Session two – target and response one = MAYTOR, target two - JUNFLIZ, response = JAYTOR. C3 could successfully self-correct on most occasions. Another interfering factor was C3’s difficulty inhibiting the lexicalisation of words on a number of occasions e.g. STARTLE instead of SARTLE and SNAIL instead of SNAITLE. C3 recalled 20 of the new words in written form making seven spelling errors (e.g. target - HAMEKIN, response = HAMKIN; target - YAMTORK, response = YAMOCK). C3 had significant word-finding difficulties evidenced by the lengthy time required to retrieve many of the words.

Table 5.15
C3's detailed performance on learning new vocabulary

Assessment (type)	Raw score	
	IR	DR
CR – NAME (S)	18	9
CR – NAME (W)	20	15
CR – SKILL (S/W)	18	3.5
CR – HABITAT (S/W)	14	10
CR – FOOD (S/W)	15	10
Recognition (L)	16	19
Recognition (R)	16	14
P-S match (P)	19	18
Syllable completion (R)	20	18

Assessment (type)	Raw score	
	IR	DR
Read aloud (R)	14	14
W-P match – NAME (L)	16	18
W-P match – NAME (R)	15	16
W-P match – SKILL (L)	20	13
W-P match – SKILL (R)	18	13
Categorisation– HABITAT/FOOD (P)	17	10
Categorisation– HABITAT/FOOD (R)	10	10
TOTAL SCORE	266	210.5

5.8.2.2 *Delayed recall*

C3 retrieved nine new words in spoken form requiring five phonemic and 13 syllable cues to aid recall and made three phonemic errors. She also recalled 15 new words in written form and made eleven spelling errors. Again she had many word-finding difficulties evidenced by slow response time but was motivated to recall the words. C3 could match the initial syllables of 18 words with their final syllable indicating that she had retained most of the new words' word form knowledge but required additional information about the new words to aid recall.

5.8.2.3 *Summary of new learning*

C3 demonstrated the learning of the new vocabulary by recalling 83% of information learned for the immediate recall assessment tasks. She retained this learning in long-term memory recalling 66% of information in delayed recall assessments, equating to remembering 80% of original information learned in the training sessions. As predicted C3 demonstrated word-finding difficulties (see section 5.8.1.3). C3 only spelled 1.5 non-words correctly at baseline measures indicating a difficulty spelling non-words yet she only made spelling errors with six out of the 20 new words. Qualitatively the characteristics of her spelling errors for the new words differed from baseline errors. Baseline errors included, for example, target – SMOKE, response = SLODGE, target – CHURSE, response = JARHA, whereas spelling errors for the new words were considered to be closer to the target word, for example, target – HAMEKIN, response = HAMKIN, target – YAMTORK, response = YAMOCK, target – WANGOR, response = WANGOL. So while it was predicted that C3 would make spelling errors on the new words (see section 5.8.1.3) she made no spelling errors on 14 of the new words and the errors that were made for the other six words were similar to the target words suggesting that these words were being stored as real words.

5.9 PARTICIPANT C4

Participant C4's personal profile is presented in Table 5.16 below. He lived with his wife and children. C4 presented with moderate right upper and lower limb hemiparesis and was independently mobile. C4 expected to return to work with reduced responsibilities. He was not receiving speech and language therapy at the time of the investigation.

Table 5.16
C4's personal, medical, language and cognitive data

<table>
<tr><th colspan="2">Personal details</th></tr>
<tr><td>Gender</td><td>M</td></tr>
<tr><td>Age</td><td>42;11</td></tr>
<tr><td>Education (yrs)</td><td>14</td></tr>
<tr><td colspan="2"><u>Pre-morbid employment</u> - Manager</td></tr>
<tr><td>Months post-stroke</td><td>13</td></tr>
<tr><td colspan="2"><u>Stroke details</u> - Left intra-cerebral bleed and lateral ventricle rupture</td></tr>
<tr><td>HADs anxiety</td><td>1</td></tr>
<tr><td>HADs depression</td><td>1</td></tr>
<tr><td>Independent learning</td><td>120mins</td></tr>
</table>

<table>
<tr><th>Language screening scores</th><th>Word</th><th colspan="2">N-word</th></tr>
<tr><td>Listening lexical decision</td><td>8</td><td colspan="2">7</td></tr>
<tr><td>Repetition</td><td>8</td><td colspan="2">7</td></tr>
<tr><td>Reading lexical decision</td><td>8</td><td colspan="2">7</td></tr>
<tr><td>Read aloud</td><td>7</td><td colspan="2">4</td></tr>
<tr><td>Spelling</td><td>5.5</td><td colspan="2">2.5</td></tr>
<tr><td>Categorisation</td><td>15</td><td>15</td><td>14</td></tr>
<tr><td>Naming</td><td colspan="3">12</td></tr>
<tr><td>CLQT language</td><td>21</td><td colspan="2">Moderate</td></tr>
<tr><td>Aphasia score</td><td>120</td><td colspan="2">90.2%</td></tr>
</table>

<table>
<tr><th colspan="5">Cognitive sub-test scores on CLQT</th><th>Stepping-stone Route</th></tr>
<tr><td>Attention</td><td>Memory</td><td>Executive function</td><td>Visuospatial skills</td><td>Clock drawing</td><td>Non-linguistic learning</td></tr>
<tr><td>122</td><td>128</td><td>25</td><td>82</td><td>10</td><td>18</td></tr>
<tr><td>Moderate</td><td>Moderate</td><td>WNL</td><td>WNL</td><td>Mild</td><td>100%</td></tr>
</table>

5.9.1 Predictive factors for learning new vocabulary

The various factors for determining predictors of new learning are discussed in section 5.4.2 and are evaluated below for C4 with reference to the data in Table 5.16.

5.9.1.1 *Personal attributes*

C4 was aged 42;11 at the time of the investigation and was one of the younger participants. Although C4 had spent only 14 years in formal education he had developed specialist skills and was manager of a manufacturing plant. His employment required him to be a strong communicator and developed skills such as, decision making and problem solving abilities and organisational and management skills (www.learndirect-advice.co.uk - profile 1061). It was predicted that C4 would learn more vocabulary than older and less educated/ skilled participants. C4's HADs self-rating for anxiety and depression were within normal limits and he was 13 months post-stroke.

5.9.1.2 *Cognitive abilities and the capacity to learn*

The cognitive sub-tests of the CLQT indicated that C4 had moderate attention and memory difficulties, mild clock drawing skills and executive functioning, and visuospatial skills were within normal limits. It was felt that this was reflective of C4's word-finding difficulties in the story-retelling task and word-finding difficulties in generation naming tasks. Memory impairment would predict some difficulty learning and recalling the new vocabulary (see section 2.6.3.3) however, C4 demonstrated the capacity to learn and recall new information by recalling 100% of the non-linguistic task for both immediate and delayed recall.

5.9.1.3 *Severity of aphasia*

The language sub-test of the CLQT suggested that C4 had moderate language difficulties. His language screening scores are presented in Table 5.16 for each task and mapped on to a cognitive neuropsychology model in Figure 5vi below. C4's data (see Table 5.16 and Figure 5vi below) indicated that he had word-finding difficulties, which is revealed in qualitative data where C4 made semantic errors when naming (although he self-corrected accurately). He also had difficulties in reading aloud and spelling non-words and also made some spelling errors with familiar words (suggesting impairment to LPC, OOL, PLC, POB and GOB pathways).

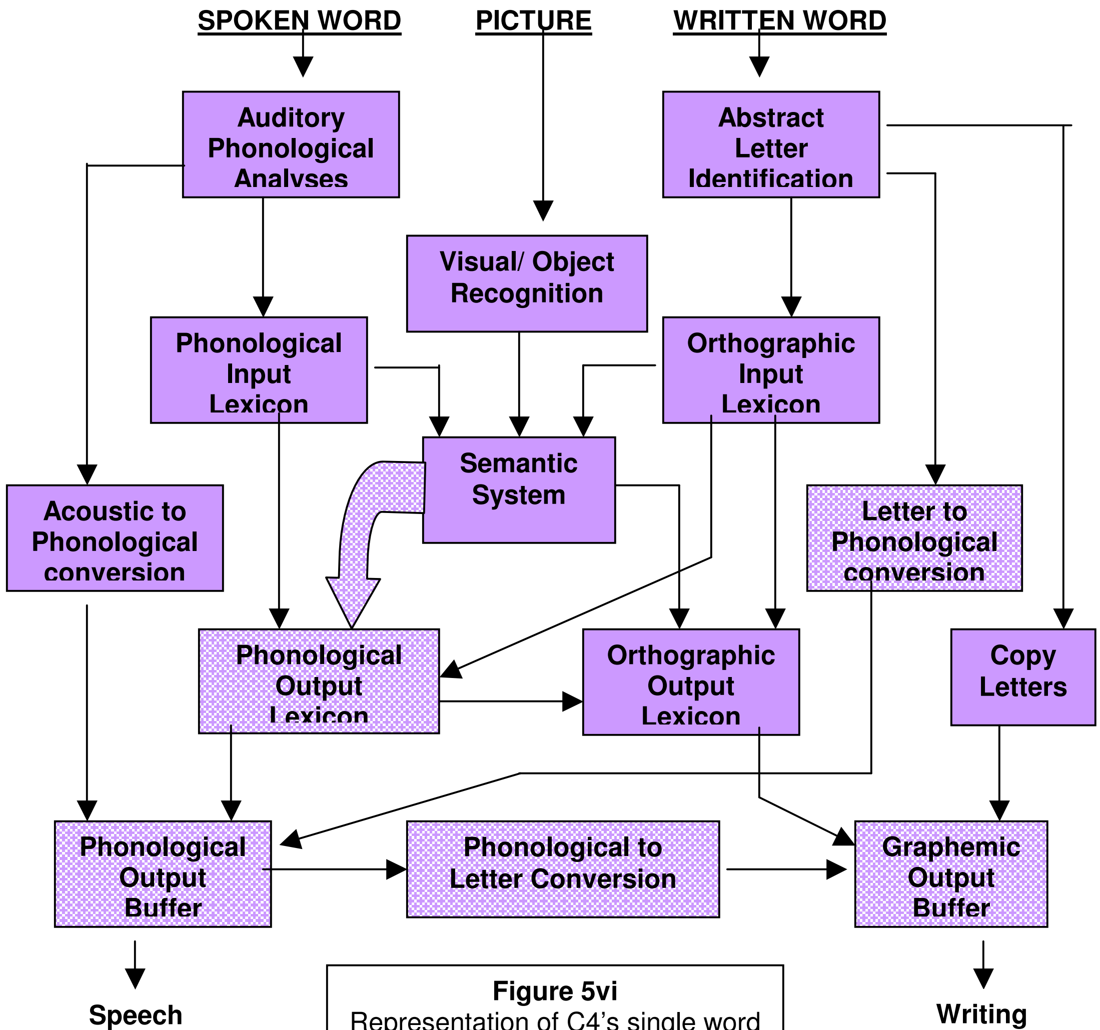


Figure 5vi
Representation of C4's single word processing abilities

C4's narration of the Cinderella story is presented in Appendix 5.3d. Perseveration and lexicalisation were characteristic of C4's aphasia. It was predicted that C4 would be able to demonstrate learning of the new vocabulary but may have difficulty reading aloud and spelling the new word forms. Word finding difficulties may also affect the ability to demonstrate this new learning both in spoken form and written form.

5.9.1.4 Rehearsal and consolidation of learning

C4 utilised the full 30 minutes of independent learning time for all training sessions to practise the new vocabulary. During this time he wrote the creature names beside their images, listened to the audio recording a number of times each session. He also categorised the creature details in terms of habitat and food.

5.9.2 Demonstration of learning the new vocabulary

C4's performance on each assessment task is presented in Table 5.17 below with a summary of his ability to learn the new vocabulary for both immediate and delayed recall assessments.

5.9.2.1 Immediate recall

C4 recalled seven of the new words in spoken form making two phonemic errors (i.e. target - fʉtaɹg, response = fʉkaɹg; target - dɹipl, response = dɹidl). He required two phonemic and 16 syllable cues to aid recall – only seven of the cues were successful. Verbal recall was hindered by the lexicalisation of words and perseveration e.g. target - meɪtɔɹ, response = meɪflaʉɹ; target - dʒʌnflɪz, response = dʒʌnflaʉəɹ; target - lʌndɹəl, response = lʌnd/n). C4 also recalled seven new words in written form and required five syllable cues to aid recall. He made spelling errors on all seven responses (e.g. target - DREEPLE, response = BWEEDLE; target - FUTARG, response = FUTUG). While C4 achieved 100% recognition on both listening and reading recognition tasks he made six false positive responses to the listening task and two false positive responses during the reading task. C4 was unable to recall three skills in the immediate recall of their training sessions. However, he recalled these same skills in a subsequent session when attempting to name other skills. This was evidence of implicit learning. Although C4 categorised the creatures into food and habitat as a learning strategy, he was unable to recall the items in this manner.

Table 5.17
C4's detailed performance on learning new vocabulary

Assessment (type)	Raw score IR	Raw score DR
CR – NAME (S)	7	6
CR – NAME (W)	7	5
CR – SKILL (S/W)	0	0
CR – HABITAT (S/W)	2	1
CR – FOOD (S/W)	13	2
Recognition (L)	20	20
Recognition (R)	20	19
P-S match (P)	15	15
Syllable completion (R)	16	16

Assessment (type)	Raw score IR	Raw score DR
Read aloud (R)	13	18
W-P match – NAME (L)	20	8
W-P match – NAME (R)	20	12
W-P match – SKILL (L)	20	7
W-P match – SKILL (R)	18	9
Categorisation– HABITAT/FOOD (P)	15	2
Categorisation– HABITAT/FOOD (R)	9	4
TOTAL SCORE	**215**	**144**

Occasionally, C4 was unable to recall target responses but could recall some word knowledge. Some examples of include: stating that the word was the longest that session, how many words had a certain number of syllables or the number of creatures that had the same type of habitat and food. C4 was able to match all 20 creature' names to their images both in listening and reading form. He could also match the initial syllables of 16 words with their final syllable indicating that he held knowledge about the new words but required additional information about the new words to aid recall.

5.9.2.2 Delayed recall

C4 recalled six new words in spoken form for the delayed recall assessments requiring two phonemic and 17 syllable cues. He also recalled five in written form and required one written cue. While unable to recall many of the word forms spontaneously, he demonstrated source memory when he recalled exactly when three of the words were initially presented in the training sessions (for example, THAT WAS ON DAY TWO I THINK, THE FIRST ONE ON DAY THREE etc.) and there were also two of these observations that had some information correct, FIRST ONE ON THIRD DAY (it was the first one presented but on the first day), LAST ONE ON THE THIRD DAY (it was the last one but on the fourth day). While C4 achieved 100% recognition on the listening and 95% for reading recognition responses he made nine false positive responses (listening) and five false positive responses for the reading recognition task. C4 could however match initial syllables for 16 new words with their final syllable. As Table 5.15 indicates C4 correctly matched more written words to the target picture than when he heard the words in spoken form.

5.9.2.3 Summary of new learning

Although C4 demonstrated some learning of the new vocabulary word-finding difficulties appeared to limit this demonstration. He recalled 67% of information learned for immediate recall and 45% for delayed recall assessments. This indicated that 67% of information learned during the training sessions was retained in long-term memory. As predicted C4’s word-finding difficulties affected the demonstration of his learning for cold recall tasks.

5.10 PARTICIPANT C5

Participant C5's personal details are presented in Table 5.18. He was single and lived with his elderly father. He presented with moderate dominant upper and lower limb hemiparesis following his multiple strokes (all left hemisphere) and was independently mobile. C5 enjoyed watching television, in particular sport.

Table 5.18
C5's personal, medical, language and cognitive data

<table>
<tr><th colspan="2">Personal details</th><th></th><th>Language screening scores</th><th colspan="3">Word</th><th colspan="3">N-word</th></tr>
<tr><td>Gender</td><td>M</td><td></td><td>Listening lexical decision</td><td colspan="3">8</td><td colspan="3">8</td></tr>
<tr><td>Age</td><td>56;03</td><td></td><td>Repetition</td><td colspan="3">8</td><td colspan="3">8</td></tr>
<tr><td>Education (yrs)</td><td>13</td><td></td><td>Reading lexical decision</td><td colspan="3">8</td><td colspan="3">8</td></tr>
<tr><td colspan="2">Pre-morbid employment - Army Chef</td><td></td><td>Read aloud</td><td colspan="3">8</td><td colspan="3">6</td></tr>
<tr><td>Months post-stroke</td><td>20</td><td></td><td>Spelling</td><td colspan="3">5</td><td colspan="3">4</td></tr>
<tr><td colspan="2">Stroke details – Multiple left hemispheric infarcts</td><td></td><td>Categorisation</td><td colspan="2">15</td><td colspan="2">15</td><td colspan="2">15</td></tr>
<tr><td>HADs anxiety</td><td>6</td><td></td><td>Naming</td><td colspan="6">11.5</td></tr>
<tr><td>HADs depression</td><td>10</td><td></td><td>CLQT language</td><td colspan="3">20</td><td colspan="3">Severe</td></tr>
<tr><td>Independent learning</td><td>109mins</td><td></td><td>Aphasia score</td><td colspan="3">127.5</td><td colspan="3">95.9%</td></tr>
</table>

<table>
<tr><th colspan="5">Cognitive scores on CLQT</th><th>Stepping-stone Route</th></tr>
<tr><td>Attention</td><td>Memory</td><td>Executive function</td><td>Visuospatial skills</td><td>Clock drawing</td><td>Non-linguistic learning</td></tr>
<tr><td>148</td><td>129</td><td>20</td><td>79</td><td>0</td><td>13</td></tr>
<tr><td>Mild</td><td>Moderate</td><td>Mild</td><td>Mild</td><td>Severe</td><td>72%</td></tr>
</table>

5.10.1 Predictive factors for learning new vocabulary

The various factors for determining predictors of new learning are discussed in section 5.4.2 and are evaluated below for C5 with reference to the data in Table 5.18.

5.10.1.1 Personal attributes

C5 was aged 56.03 at the time of the investigation and was one of the older participants. C5 spent 13 years in formal education and had worked as a chef in the army. The skills he required for this included, to be able to operate multiple tasks, be creative and imaginative, have good organisational skills and to have good communication skills (www.learndirect-advice.co.uk - profile 151). It was predicted that C5 would learn less vocabulary than younger participants and also less than participants with more education. C5's self-rating for anxiety was considered within normal limits while his score for depression was 'borderline abnormal' and he was 20 months post-stroke. As the literature suggests that emotional difficulties impact upon cognitive and linguistic performance (see section 2.6.3.2) it was predicted that C5's emotional status might negatively impact upon his ability to learn the new vocabulary.

5.10.1.2 Cognitive abilities and the capacity to learn

The cognitive sub-tests of the CLQT indicated that C5 had mild deficits in attention, executive function and visuospatial skills. As he was able to copy the new words accurately and draw detailed pictures of the creatures the mild impairment of visuospatial skills was not considered to affect the training or assessment tasks. C5's clock drawing skills were severely impaired. His moderate memory impairment was considered to be reflective of C5's difficulties remembering the details of the story-retelling task and word-finding difficulties in generation naming tasks. Attention and memory impairments would predict some difficulty learning and recalling the new vocabulary (see section 2.6.3.3) and while C5 demonstrated some ability to learn new information he only achieved 72% accuracy in learning the non-linguistic task.

5.10.1.3 Severity of aphasia

The language sub-test of the CLQT suggested that C5 had severe language difficulties. His language screening scores are presented in Table 5.18 for each task and mapped on to a cognitive neuropsychology model in Figure 5vii below.

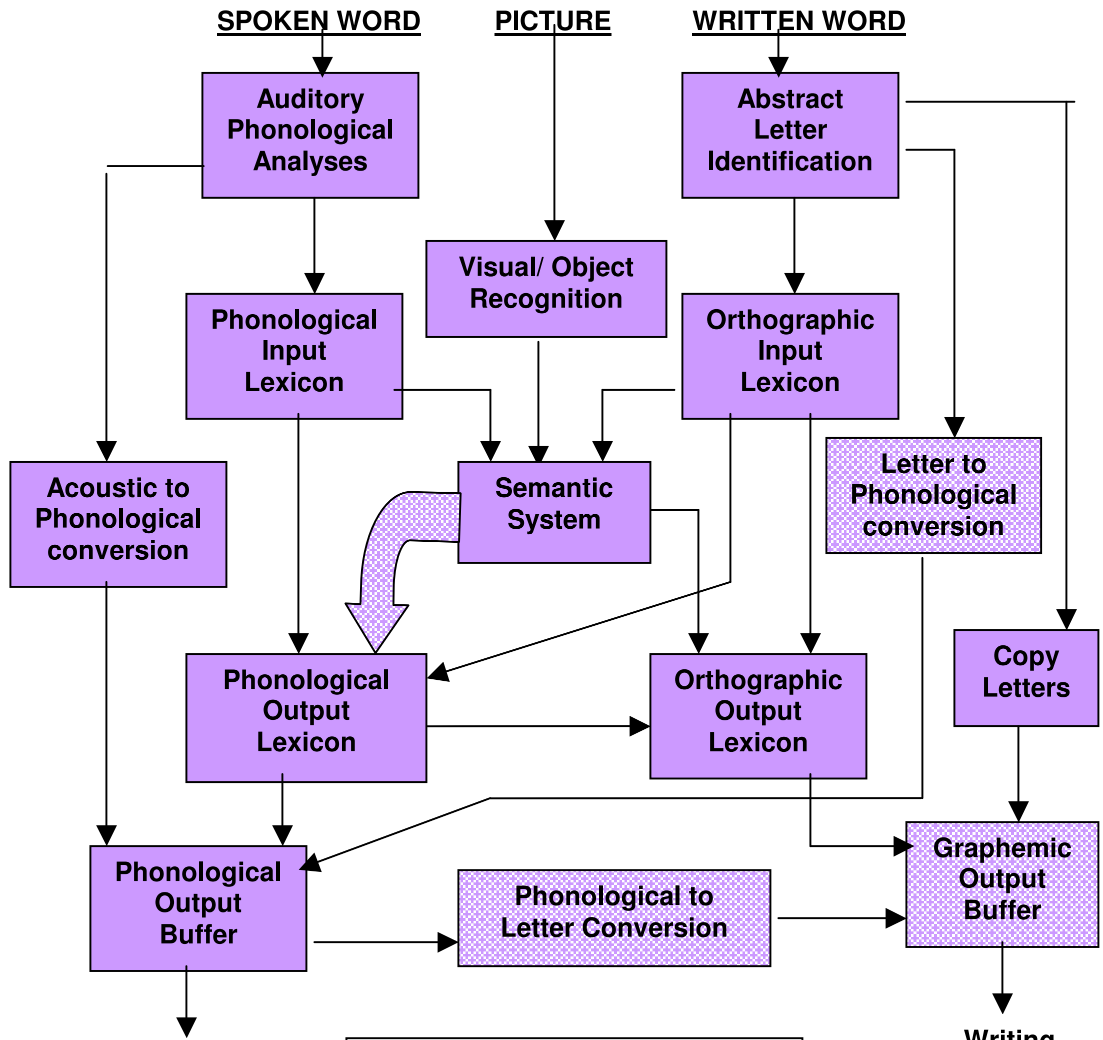


Figure 5vii
Representation of C5's single word processing abilities

C5's data (see Table 5.18 and Figure 5vii above) indicated that his main difficulties were reading aloud and spelling non-words (suggesting impairment to LPC, POB, PLC and GOB pathways). C5 did not know the Cinderella story or any other fictional stories so he was asked to describe his day thus far, which he found very difficult to respond in spoken form and was unable to give any written response (see Appendix 5.3e). C5's conversational speech featured word-finding difficulties with prolonged delays when retrieving target words. Although C5 knew the name of letters when writing he often asked questions such as "how do you write an R?" It would be predicted that C5 would demonstrate learning of the new vocabulary in spoken form and in writing but may have difficulties spelling the novel words. Word finding difficulties may also be a feature of the new learning.

5.10.1.4 Rehearsal and consolidation of learning

C5 employed 91% of the allocated independent learning time to rehearse and consolidate the new learning. During this time he wrote the creature names beside their images and listened to the audio recording a number of times for each session. He was also heard rehearsing the words under his breath.

5.10.2 Demonstration of learning the new vocabulary

C5's performance on each assessment task is presented in Table 5.19 below with a summary of his ability to learn the new vocabulary for both immediate and delayed recall assessments.

5.10.2.1 Immediate recall

C5 recalled 11 creature names in spoken form requiring cueing for all 20 creatures to aid recall (five phonemic and 15 syllable cues) and made one phonemic error. Occasionally C5 made semantic errors with already familiar words, for example, target word - FRUIT, response = VEGETABLES and VEGETATION. There was some within-session interference from the new words (e.g. session one - target and response - ʃɔ˩˥paɪn, target - sa˩˥tl, response = sa˩˥taɪn; session two – target and response -meɪtɔ˩˥; target - dʒʌnflɪz, response = dʒʌnfɔ˩˥). C5 recalled 14 new words in written form and made nine spelling errors (for example, target -FEETOKEL, response = FEETOKIL; target - SARTLE, response = SARTINE).

Table 5.19
C5's detailed performance on learning new vocabulary

Assessment (type)	Raw score	
	IR	DR
CR – NAME (S)	11	3
CR – NAME (W)	14	10
CR – SKILL (S/W)	2	0
CR – HABITAT (S/W)	6	6
CR – FOOD (S/W)	10	6
Recognition (L)	17	17
Recognition (R)	18	17
P-S match (P)	14	17
Syllable completion (R)	15	13

Assessment (type)	Raw score	
	IR	DR
Read aloud (R)	19	17
W-P match – NAME (L)	18	8
W-P match – NAME (R)	14	12
W-P match – SKILL (L)	11	10
W-P match – SKILL (R)	8	10
Categorisation– HABITAT/FOOD (P)	12	8
Categorisation– HABITAT/FOOD (R)	10	5
TOTAL SCORE	199	159

Interference from previous sessions was also mirrored in the written task. Occasionally, C5 was unable to write certain letters during written recall tasks, despite being able to name and write them accurately for previous words e.g. 'how do you write a zed?' 'I want to put an 'i' in but can't remember how to do it' and repeating letters under his breath at times. C5 recognised 17 words when heard in spoken form (for which he made one false positive response) and 18 words in written form (for which he made two false positive responses). He demonstrated further learning through matching the initial syllables for 15 words with their final syllables. Additionally, C5 matched 18 names to images (listening) and 14 (reading) further demonstrating knowledge of the new words.

5.10.2.2 Delayed recall

C5 retrieved three new words in spoken form and required 20 syllable cues to aid recall. He recalled ten words in written form making six spelling errors. Although C5 correctly recognised 17 creature names during the listening and reading tasks, he made five false positives (listening) and two false positives for the reading task. C5 matched eight words to target pictures (listening) and twelve words correctly when reading.

5.10.2.3 Summary of new learning

C5 demonstrated learning of new vocabulary recalling 62% of information from immediate recall assessments. He recalled 50% of delayed recall information retaining 80% of originally learned information. As predicted C5 had word-finding difficulties when recalling the information however, interestingly he had more difficulty recalling the associated familiar words than the new words themselves.

5.11 PARTICIPANT C6

Participant C6's personal details are presented in Table 5.20. He lived with his wife and despite residual moderate upper and lower limb dominant hemiparesis was fully mobile and independent. C6 had a history of heart problems since his early 40s. He had worn a hearing aid for many years prior to his stroke and sometimes required repetition. He was actively involved with a charity for post-stroke people. He was also in the process of writing his autobiography.

Table 5.20
C6's personal, medical, language and cognitive data

Personal details		Language screening scores	Word	N-word	
Gender	M	Listening lexical decision	8	6	
Age	56;10	Repetition	8	6	
Education (yrs)	13	Reading lexical decision	8	6	
Pre-morbid employment - Engineer		Read aloud	8	4	
Months post-stroke	13	Spelling	5	3.5	
Stroke details – Left parietal-occipital and frontal lobe		Categorisation	15	15	15
HADs anxiety	16	Naming	12		
HADs depression	10	CLQT language	23	Moderate	
Independent learning	76mins	Aphasia score	119.5	89.8%	

Cognitive sub-test scores on CLQT					Stepping-stone Route
Attention	Memory	Executive function	Visuospatial skills	Clock drawing	Non-linguistic learning
184	133	28	93	7	14
WNL	Moderate	WNL	WNL	Severe	78%

5.11.1 Predictive factors for learning new vocabulary

The various factors for determining predictors of new learning are discussed in section 5.4.2 and are evaluated below for C6 with reference to the data in Table 5.20.

5.11.1.1 Personal attributes

C6 was aged 56.10 at the time of the investigation and was one of the older participants. Although C6 had spent only 13 years in formal education he had developed specialist skills and was a self-employed engineer. These skills required him to be able to analyse and critically evaluate complex problems, have excellent communication skills and be able to categorise and plan effectively (www.learndirect-advice.co.uk - profile 357). It was predicted that C6 would learn less vocabulary than younger participants although his highly developed employment skills may facilitate this learning. C6's self-rating for anxiety was considered 'abnormal' while his score for depression was 'borderline abnormal' and he was 13 months post-stroke. As the literature suggests that emotional difficulties impact upon cognitive and linguistic performance (see section 2.6.3.2) it was predicted that C6's emotional status might negatively impact upon his ability to learn the new vocabulary.

5.11.1.2 Cognitive abilities and the capacity to learn

The cognitive sub-tests of the CLQT indicated that C6's attention, executive function and visuospatial skills were within normal limits but his memory was moderately impaired and clock drawing skills severely impaired. It was felt that this was reflective of C6's difficulties remembering the details of the story-retelling task and word-finding difficulties in generation naming tasks. Memory impairment would predict some difficulty learning and recalling the new vocabulary (see section 2.6.3.3) however, C6 demonstrated some capacity to learn and recall new information by recalling 78% of the non-linguistic task for both immediate and delayed recall.

5.11.1.3 Severity of aphasia

The language sub-test of the CLQT suggested that C6 had moderate language difficulties. His language screening scores are presented in Table 5.20 for each task and mapped on to a cognitive neuropsychology model in Figure 5viii below.

C6's data (see Table 5.20 and Figure 5viii below) indicated that he had a number of language difficulties, in particular, recognising when a word was a non-word for both spoken and written modalities (suggesting impairment to PIL and OIL pathways). He also had difficulty repeating, reading aloud and spelling non-words (suggesting impairment to APC, LPC, POB, PLC and GOB pathways).

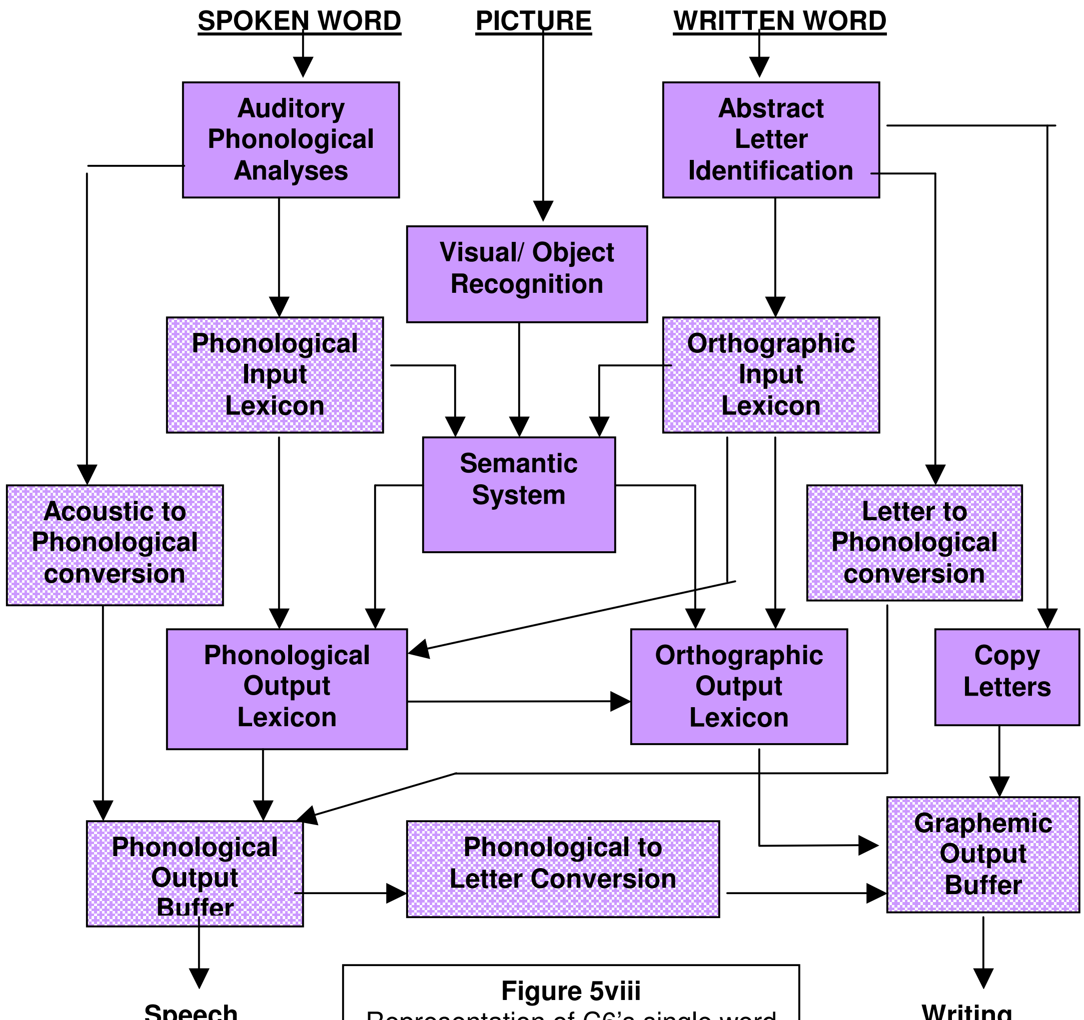


Figure 5viii
Representation of C6's single word processing abilities

Qualitatively C6's speech presented with a nasal and dysarthric quality. C6's narration of the Cinderella story is presented in Appendix 5.3f and features some word-finding difficulties with both occasional semantic and phonemic errors. It would be predicted that C6 would demonstrate learning of the new vocabulary in spoken and written format but may have difficulties spelling the novel words. Word finding difficulties may be a feature of this learning.

5.11.1.4 *Rehearsal and consolidation of learning*

C6 utilised 63% of the allocated independent learning time to rehearse and consolidate learning of the new vocabulary. During this time he wrote the creature names beside their images and listened to the audio recording a number of times for each session.

5.11.2 Demonstration of learning the new vocabulary

C6's performance on each assessment task is presented in Table 5.21 below with a summary of his ability to learn the new vocabulary for both immediate and delayed recall assessments.

5.11.2.1 *Immediate recall*

Table 5.21
C6's detailed performance on learning new vocabulary

Assessment (type)	Raw score	
	IR	**DR**
CR – NAME (S)	**11**	**2**
CR – NAME (W)	**15**	**8**
CR – SKILL (S/W)	2.5	0
CR – HABITAT (S/W)	4	6
CR – FOOD (S/W)	6	3
Recognition (L)	19	18
Recognition (R)	20	18
P-S match (P)	19	14
Syllable completion (R)	15	16

Assessment (type)	Raw score	
	IR	**DR**
Read aloud (R)	20	20
W-P match – NAME (L)	8	4
W-P match – NAME (R)	8	6
W-P match – SKILL (L)	11	13
W-P match – SKILL (R)	15	4
Categorisation– HABITAT/FOOD (P)	10	0
Categorisation– HABITAT/FOOD (R)	6	0
TOTAL SCORE	**189.5**	**132**

C6 recalled 11 new words in spoken form requiring nine phonemic and seven syllable cues. He made five phonemic errors (e.g. target - dɹipl, response = dipl; target - fitʌkəl, response = fitɔl; target - jamtɔɹk, response = jamak). C6 also recalled 15 new words in written form making 10 spelling errors (e.g. target - YAMTORK, response = YAMAK; target - POPKINEL, response = POOKIN; target - ZOODOP, response = ZOOTOK). C6 demonstrated further learning by recognising 19 creatures in listening and 20 in reading tasks with only one false positive response. C6 also demonstrated implicit learning on two occasions – named target PENTAR as <u>PEN</u>COT (when given the initial syllable as a cue) and in the following session named the target - PONCHINO, PENTAR. He was also unable to recall two skills, CREATES HARMONY and CREATES CALM in their appropriate sessions but did recall them in subsequent sessions for other target words.

5.11.2.2 Delayed recall

C6 recalled two new words in spoken form requiring six phonemic and 14 syllable cues to aid recall. He made two phonemic errors in this recall (i.e. target - sneɪtl, response = sneɪl; target - kʌ˩vɔl, response = kʌ˩nɔl). C6 also recalled eight new words in written form and all eight had spelling errors (e.g. target - CURVOL, response = KURNOL; target - POPKINEL, response = POPKRIN). C6 recognised 18 creature names from both listening and reading tasks with only one false positive. He demonstrated further learning by matching initial syllables of 16 new words with their appropriate final syllable.

5.11.2.3 Summary of new learning

C6 demonstrated learning of the new vocabulary by recalling 59% of information for immediate recall assessments. He recalled 41% of information for delayed recall assessments demonstrating that he retained 70% of the original learning in long-term memory. As predicted C6's word-finding difficulties impacted upon his learning and while he had some memory difficulties they didn't prevent him from learning some of the new vocabulary.

5.12 PARTICIPANT C7

Participant C7's personal profile is presented in Table 5.22 below. She lived alone and independently with her mother visiting daily. C7 presented with severe upper and lower limb hemiparesis (dominant side) following her stroke and mobilised with the aid of a stick. She was actively involved in a charity for post-stroke people and enjoyed attending social activities.

Table 5.22
C7's personal, medical, language and cognitive data

Personal details		**Language screening scores**	**Word**	**N-word**	
Gender	F	Listening lexical decision	8	7	
Age	51;03	Repetition	8	5	
Education (yrs)	12	Reading lexical decision	8	8	
Pre-morbid employment – factory worker		Read aloud	1	0	
Months post-stroke	29	Spelling	3	0	
Stroke details - Left hemisphere infarct		Categorisation	15	15	14
HADs anxiety	5	Naming	5		
HADs depression	4	CLQT language	11.5	Severe	
Independent learning	54mins	Aphasia score	97	72.9%	

Cognitive sub-test scores on CLQT					**Stepping-stone Route**
Attention	Memory	Executive function	Visuospatial skills	Clock drawing	Non-linguistic learning
180	101	25	94	12	17
WNL	Severe	WNL	WNL	WNL	94%

5.12.1 Predictive factors for learning new vocabulary

The various factors for determining predictors of new learning are discussed in section 5.4.2 and are evaluated below for C7 with reference to the data in Table 5.22.

5.12.1.1 Personal attributes

C7 was aged 51;03 at the time of the investigation and was one of the older participants. She experienced 12 years in education and worked in a factory requiring basic literacy skills and good attention and concentration skills such as being methodical and dexterous (www.learndirect-advice.co.uk - profile 811). C7's self-rating for anxiety and depression was considered to be within normal limits and she was 29 months post-stroke. It was predicted that being one of the older participants and consideration of her level of education and skill in employment C7 would not learn as much new vocabulary as younger more educated and skilled participants.

5.12.1.2 Cognitive abilities and the capacity to learn

The cognitive sub-tests of the CLQT indicated that C7's cognitive abilities were within normal limits with the exception of memory, which indicated severely impaired memory. Such impairment would predict a difficulty learning and recalling the new vocabulary (see section 2.6.3.3) however, as with C2 (see section 5.7.1.2) it was felt that this score did not give an accurate reflection of C7's memory due to her severe aphasia. Additionally, she demonstrated the capacity to recall newly learned information by recalling 94% of the non-linguistic task for both immediate and delayed recall.

5.12.1.3 Severity of aphasia

The language sub-test of the CLQT suggested that C7 had severe language difficulties. Her language screening scores are displayed in Table 5.22 for each task and mapped on to a cognitive neuropsychology model in Figure 5ix below. C7's data (see Table 5.22 and Figure 5ix) indicated that she had a number of language difficulties at single word level. While she could recognise spoken and written single words C7 had severe expressive aphasia affecting her ability to repeat and read aloud non-words (suggesting impairment to APC, POB, an LPC pathways), spell words and non-words (suggesting impairment to PLC, POB, PLC and GOB pathways).

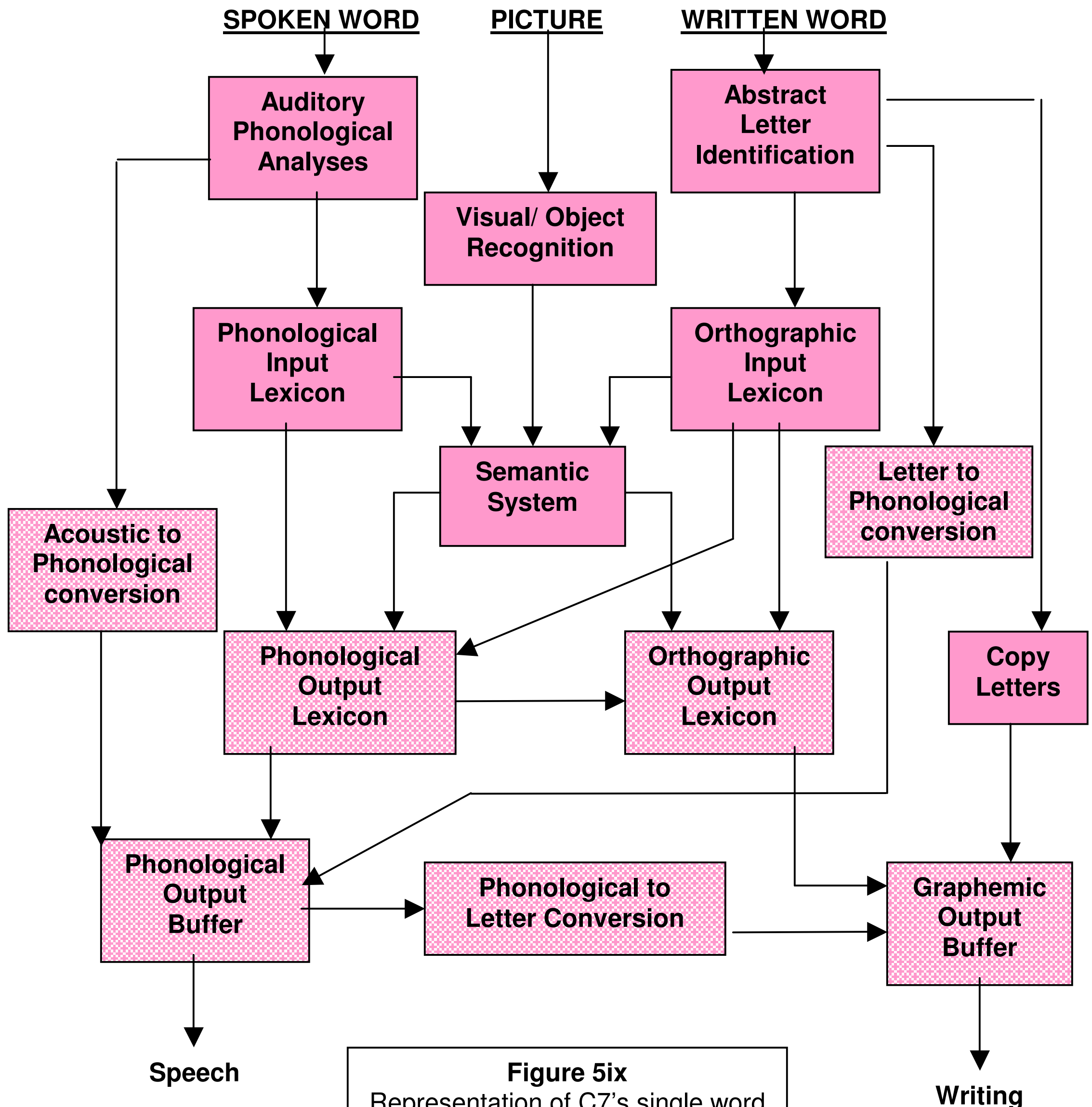


Figure 5ix
Representation of C7's single word processing abilities

C7's ability to categorise pictures and words suggested that she could adequately access her semantic system for meaning suggesting that her naming difficulties were due to speech output problems (phonological output lexicon and phonological output buffer). It was predicted that C7 would be unable to demonstrate the learning of the new vocabulary in spoken or in written form but would evidence new learning through picture/ word matching tasks, number of syllables and syllable matching. C7's narration of the Cinderella story is presented in Appendix 5.3h – she was unable to attempt written narration.

5.12.1.4 Rehearsal and consolidation of learning

C7 rehearsed the new vocabulary for 45% of the time allocated for independent learning. During this time she looked at the details and listened to the audio recording a number of times for each session.

5.12.2 Demonstration of learning the new vocabulary

C7's performance on each assessment task is presented in Table 5.23 below with a summary of her ability to learn the new vocabulary for both immediate and delayed recall assessments.

5.12.2.1 Immediate recall

Table 5.23
C7's detailed performance on learning new vocabulary

Assessment (type)	Raw score	
	IR	DR
CR – NAME (S)	3	0
CR – NAME (W)	0	0
CR – SKILL (S/W)	3	0.5
CR – HABITAT (S/W)	10	4
CR – FOOD (S/W)	8	3
Recognition (L)	15	20
Recognition (R)	20	20
P-S match (P)	12	18
Syllable completion (R)	13	7

Assessment (type)	Raw score	
	IR	DR
Read aloud (R)	0	0
W-P match – NAME (L)	11	3
W-P match – NAME (R)	11	6
W-P match – SKILL (L)	11	11
W-P match – SKILL (R)	13	7
Categorisation– HABITAT/FOOD (P)	15	7
Categorisation– HABITAT/FOOD (R)	10	4
TOTAL SCORE	155	110.5

C7 recalled three new words in spoken form – one word with a phonemic error - requiring one phonemic and 13 syllable cues. She was unable to recall any of the new words in written form. While C7 recognised 15 (listening) and 20 (reading) words she made 15 false positive responses, one false negative in listening modality and seven for reading tasks. However, she did demonstrate learning by matching 11 names to target pictures in both listening and reading modalities. She also matched the correct number of syllables to 12 words and matched the initial syllables of 13 new words with their final syllable. This indicated that C7 did learn some of the new words although she was unable to demonstrate this learning either in spoken or in written form.

5.12.2.2 Delayed recall

C7 did not recall any of the new words for this assessment despite receiving 20 syllable cues. She did identify all 20 words in the listening and reading recognition tasks, however as with the immediate recall she made 18 false positive responses and two false negative for the listening tasks and 19 false positives and one false negative for the reading component. C7 did however, match three words (listening) and six written words (reading) to target pictures. She also matched 18 words with the correct syllable count and was able to match initial syllables for seven words to their final syllable.

5.12.2.3 Summary of new learning

C7 recalled 48% of information for immediate recall assessments. However, as discussed (see section 5.12.2.1) she gave some false positive and negative responses for the recognition tasks possibly suggesting that this score may overestimate her true learning abilities. C7 recalled 35% of information for the delayed recall assessments suggesting she retained 71% of information learned from original training sessions. Again however, this may be an overestimation of her true retention in long-term memory. As predicted C7 had great difficulty demonstrating her learning either in spoken or written form.

5.13 PARTICIPANT C8

Participant C8's personal details are presented on Table 5.24. He lived alone and was independent despite arthritis and obesity affecting mobility. Since his stroke main activities included watching television and walking to the local shops. He occasionally travelled by train to visit his family.

Table 5.24
C8's personal, medical, language and cognitive data

Personal details	
Gender	M
Age	55;08
Education (yrs)	11
Pre-morbid employment – Miner and then Ship Stewart	
Months post-stroke	5
Stroke details - Left fronto-parietal and lateral ventricle infarcts	
HADs anxiety	5
HADs depression	3
Independent learning	80mins

Language screening scores	**Word**	**N-word**	
Listening lexical decision	8	5	
Repetition	6	3	
Reading lexical decision	8	8	
Read aloud	2	1	
Spelling	5.5	2.5	
Categorisation	15	14	15
Naming	6		
CLQT language	16	Severe	
Aphasia score	99	74.4%	

Cognitive sub-test scores on CLQT					**Stepping-stone Route**
Attention	Memory	Executive function	Visuospatial skills	Clock drawing	Non-linguistic learning
195	114	26	99	10	18
WNL	Moderate	WNL	WNL	Mild	100%

5.13.1 Predictive factors for learning new vocabulary

The various factors for determining predictors of new learning are discussed in section 5.4.2 and are evaluated below for C8 with reference to the data in Table 5.24.

5.13.1.1 Personal attributes

C8 was aged 55;08 at the time of the investigation and was one of the older participants. C8 spent 11 years in education and was previously employed as a miner (www.stepfour.com/jobs/850381010.htm) and then as a stewart on a ship (www.stepfour.com/jobs/350677026.htm). Both of these jobs involved manual labour requiring good attention and concentration skills. C8's self-rating for anxiety and depression was considered to be within normal limits and he was five months post-stroke. In consideration of C8's age, years in education and employment skills it would be anticipated that he would not learn as many words as other younger and more educated participants. Additionally, as he was only five months post-stroke he may not learn as many words as people with more chronic aphasia (see section 5.4.2.1).

5.13.1.2 Cognitive abilities and the capacity to learn

The cognitive sub-tests of the CLQT indicated that C8's attention, executive function and visuospatial skills were within normal limits and he had mild difficulties completing the clock drawing task. He presented with moderate memory impairment, which was felt to be a reflection of his severe aphasia. Memory impairment would predict difficulty learning and recalling the new vocabulary (see section 2.6.3.3) however as with participant C2 (see section 5.7.1.2) it was felt that the CLQT score did not give an accurate reflection of C8's memory. He demonstrated the capacity to recall newly learned information by recalling 100% of the non-linguistic task for immediate and delayed recall.

5.13.1.3 Severity of aphasia

The language sub-test of the CLQT suggested that C8 had severe language difficulties. His language screening scores are displayed in Table 5.24 for each task and mapped on to a cognitive neuropsychology model in Figure 5x below. C8's data (see Table 5.24 and Figure 5x below) indicated that he had a number of language difficulties at single word level.

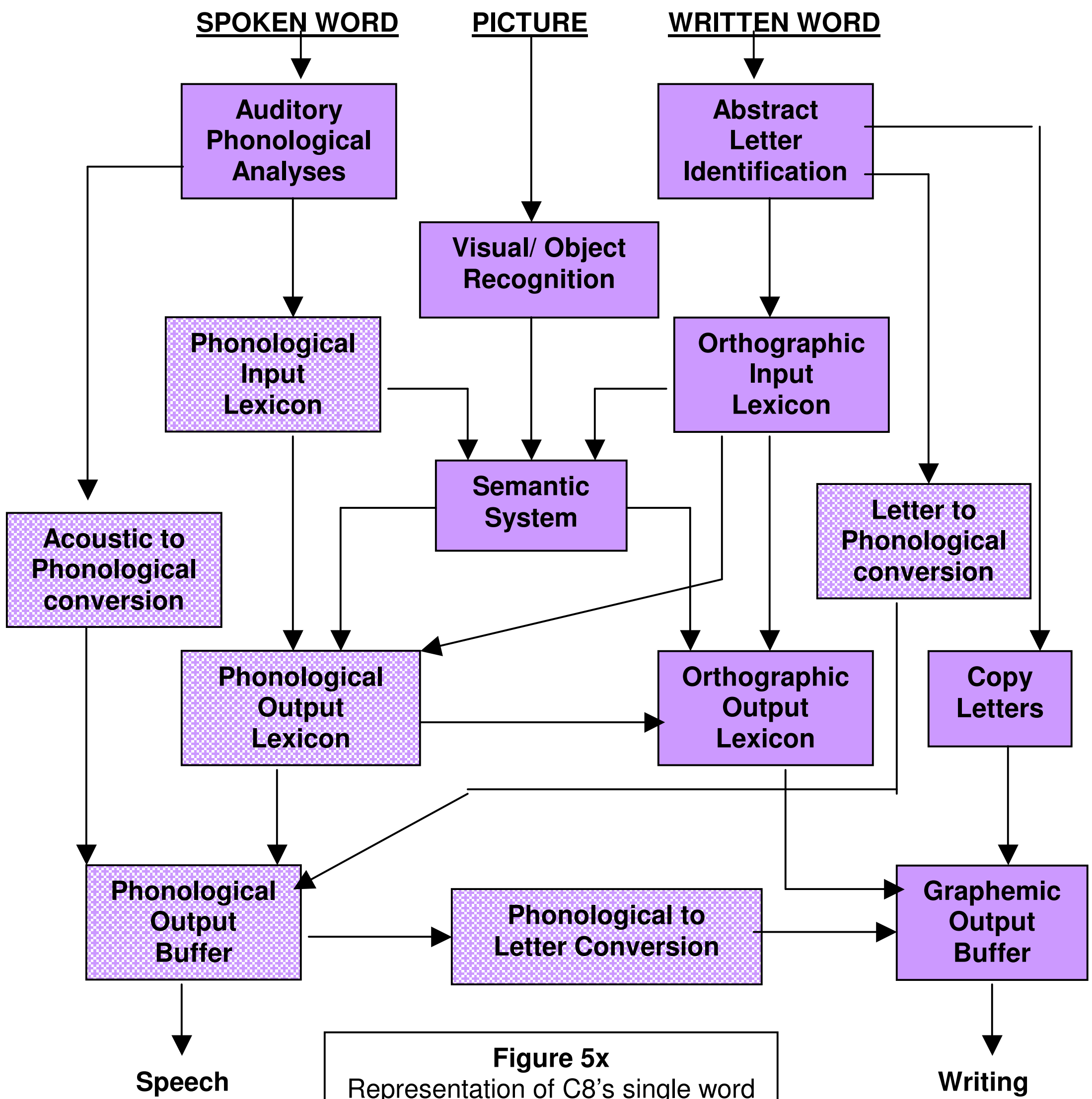


Figure 5x
Representation of C8's single word processing abilities

C8's ability to categorise pictures and words suggested that he could adequately access his semantic system and on the whole he was able to write real words correctly. However, C8 had some difficulty differentiating real from hearing non-words (suggesting impairment to PIL pathway). Significantly, he demonstrated severe impairment with all spoken output, i.e. repetition of some words and non-words, reading aloud words and non-words, spoken naming and difficulties spelling non-words (suggesting impairment to PIL, APC, POL, OIL, POB, LPC and PLC pathways). C8's speech was characteristic of dyspraxia where he groped for the target sound and frequently self-corrected in an attempt to achieve the correct word. On most occasions C8 did not achieve the target words. His low score in naming pictures was felt to be exacerbated by dyspraxic speech where he could retrieve the words from his semantic system but had difficulties articulating the words accurately. C8's spoken and written narration of the Cinderella story is presented in 5.3h. It was predicted that C8 would be able to demonstrate the learning of the new vocabulary but would contain articulation and spelling errors.

5.13.1.4 Rehearsal and consolidation of learning

C8 utilised 46% of the allocated independent learning time to rehearse and consolidate the learning of the new vocabulary. During this time he completed the practise assessments and played the audio recording once for each session.

5.13.2 Demonstration of learning the new vocabulary

C8's performance on each assessment task is presented in Table 5.25 below with a summary of his ability to learn the new vocabulary for both immediate and delayed recall assessments.

5.13.2.1 Immediate recall

C8 recalled five words in spoken form requiring two phonemic and nine syllable cues to aid recall. C8 made phonemic errors for three of the words (e.g. target fʉtaːg, response = kʉtaː). C8 recalled 13 new words in written form and only required one letter cue. He made spelling errors for eight of these words (e.g. target - MAYTOR, response = MATLOR; target - FEETOKEL, response = FREETOL). While C8 recognised 13 (listening) and 11(reading) words he made four false positive and two false negative responses for the listening task. He matched the correct number of syllables with target pictures for 17 words and 11 initial syllables with correct final syllables. C8 further demonstrated his learning by matching 12 names to target pictures (listening) and 13 in reading format.

Table 5.25
C8's detailed performance on learning new vocabulary

Assessment (type)	Raw score	
	IR	DR
CR – NAME (S)	5	2
CR – NAME (W)	13	6
CR – SKILL (S/W)	0.5	0
CR – HABITAT (S/W)	5	7
CR – FOOD (S/W)	4	6
Recognition (L)	13	14
Recognition (R)	11	7
P-S match (P)	17	15
Syllable completion (R)	11	10

Assessment (type)	Raw score	
	IR	DR
Read aloud (R)	14	1
W-P match – NAME (L)	12	6
W-P match – NAME (R)	13	9
W-P match – SKILL (L)	11	5
W-P match – SKILL (R)	6	4
Categorisation– HABITAT/FOOD (P)	8	7
Categorisation– HABITAT/FOOD (R)	11	3
TOTAL SCORE	154.5	102

5.13.2.2 Delayed recall

C8 recalled two words in spoken form in response to nine spoken syllable cues and recalled six in written form. He also matched 6 new words (listen) and nine new words (reading) to the correct image. C8 recognised 14 (listening) and 11 (reading) words as known to him and made three false positive responses for this task. He also demonstrated memory for the new word forms by correctly matching 15 images to the correct number of syllables and matched 10 initial syllables to final syllables. This indicated that C8 had retained some of the new vocabulary that he had learned.

5.13.2.3 Summary of new learning

C8 recalled 48% of information learned for immediate recall assessments. He recalled 32% in delayed recall assessments indicating that he had retained 66% of original information learned in long-term memory. C8 made some false recognition errors perhaps slightly overestimating his learning ability. As predicted C8 had a lot of difficulty demonstrating his learning in spoken format.

5.14 PARTICIPANT C9

Participant C9's personal profile is presented in Table 5.26. She presented with severe upper and lower limb hemiparesis (dominant hemisphere) and used a wheelchair and stair lift to mobilise. She lived alone with social services help for activities of daily living. C9 had a history of severe depression and received electro-current therapy treatment following her stroke.

Table 5.26
C9's personal, medical, language and cognitive data

Personal details	
Gender	F
Age	57;07
Education (yrs)	11
Pre-morbid employment – School dinner lady and cleaner	
Months post-stroke	114
Stroke details - Left fronto-parietal and Right internal capsule infarct	
HADs anxiety	14
HADs depression	10
Independent learning	85mins

<table>
<tr><th>Language screening scores</th><th colspan="2">Word</th><th colspan="2">N-word</th></tr>
<tr><td>Listening lexical decision</td><td colspan="2">7</td><td colspan="2">7</td></tr>
<tr><td>Repetition</td><td colspan="2">6</td><td colspan="2">1</td></tr>
<tr><td>Reading lexical decision</td><td colspan="2">8</td><td colspan="2">7</td></tr>
<tr><td>Read aloud</td><td colspan="2">3</td><td colspan="2">0</td></tr>
<tr><td>Spelling</td><td colspan="2">0</td><td colspan="2">0</td></tr>
<tr><td>Categorisation</td><td>15</td><td colspan="2">15</td><td>15</td></tr>
<tr><td>Naming</td><td colspan="4">5</td></tr>
<tr><td>CLQT language</td><td colspan="2">18</td><td colspan="2">Severe</td></tr>
<tr><td>Aphasia score</td><td colspan="2">89</td><td colspan="2">66.9%</td></tr>
</table>

Cognitive sub-test scores on CLQT					**Stepping-stone Route**
Attention	Memory	Executive function	Visuospatial skills	Clock drawing	Non-linguistic learning
60	74	17	50	0	18
Moderate	Severe	Moderate	Moderate	Severe	100%

5.14.1 Predictive factors for learning new vocabulary

The various factors for determining predictors of new learning are discussed in section 5.4.2 and are evaluated below for C9 with reference to the data in Table 5.26.

5.14.1.1 Personal attributes

C9 was aged 57;07 at the time of the investigation and was one of the oldest participant. She had experienced 11 years in education and was previously employed as a school dinner lady and cleaner. These jobs involve mainly light manual work and require basic literacy and numeracy skills related to reading and interpreting cleaning-fluid instructions (www.learndirect-advice.co.uk - profile 257 and 1282). C's self-rating for anxiety was rated as 'abnormal' and depression as 'borderline abnormal' and she was 114 months post-stroke. It was predicted that C's personal attributes would not contribute favourably to the learning of new vocabulary. Due to C9's age, level of education and skills developed in her employment, coupled with her high levels of anxiety and depression it would be expected that she would not learn as many new words as other participants with more favourable profiles.

5.14.1.2 Cognitive abilities and the capacity to learn

The cognitive sub-tests of the CLQT indicated that C9 had moderate attention, executive function and visuospatial skills impairment with severe memory processing and clock drawing abilities. Although C9's visuospatial skills were moderately impaired she was able to draw detailed pictures of the creatures and copy their names accurately and legibly, therefore it was not expected to affect the training or assessment tasks. The severity of C9's cognitive abilities would predict a difficulty learning and recalling new vocabulary (see section 2.6.3.3). However, she demonstrated the capacity to learn by achieving 100% on the non-linguistic learning task for both immediate and delayed recall.

5.14.1.3 Severity of aphasia

The language sub-test of the CLQT suggested that C9 had severe language difficulties. C9's language screening scores are displayed in Table 5.26 for each task and mapped on to a cognitive neuropsychology model in Figure 5xi below.

C9's data (see Table 5.26 and Figure 5xi below) indicated that she had a number of language difficulties at single word level.

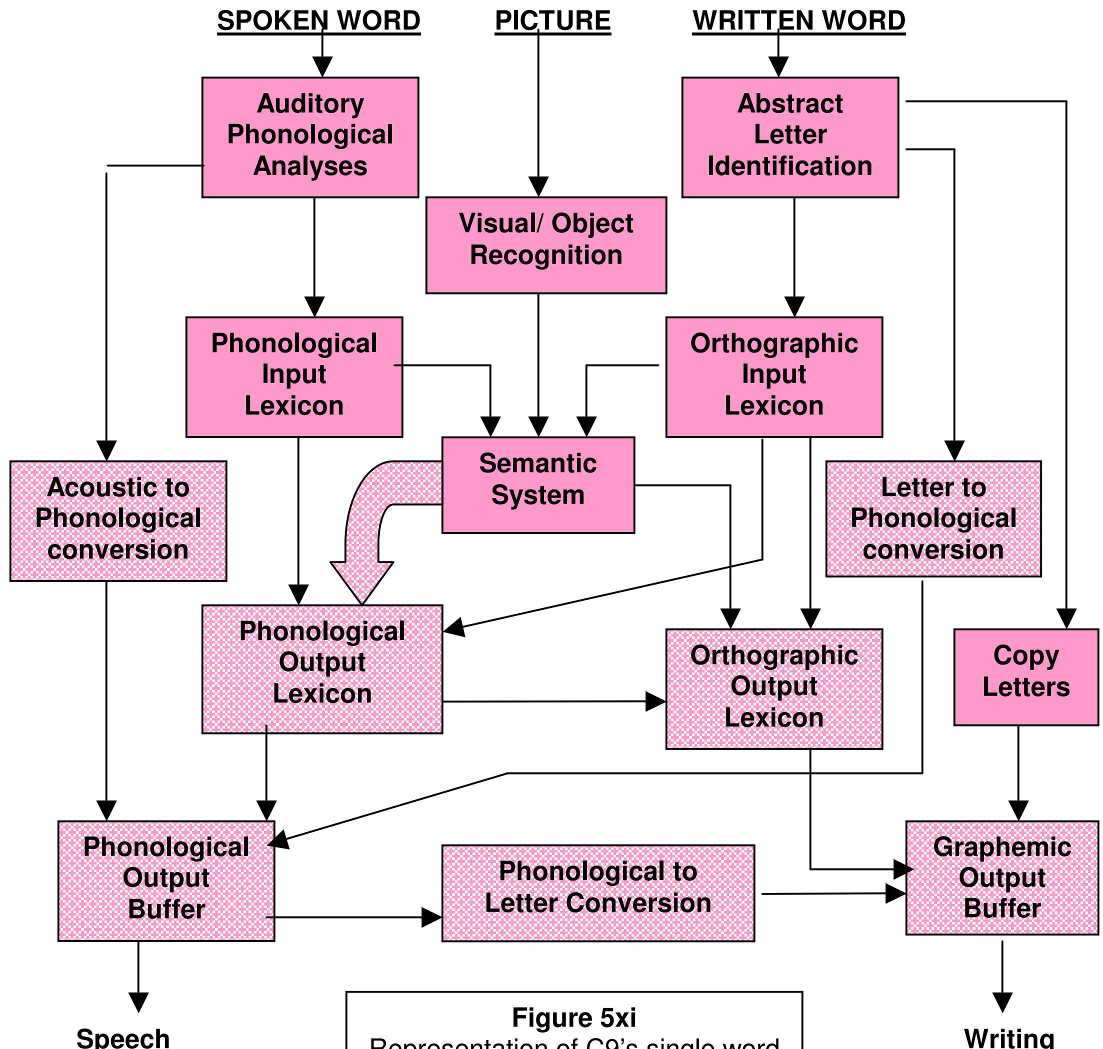


Figure 5xi
Representation of C9's single word processing abilities

C9's ability to categorise pictures and written words suggested that she could adequately access her semantic system. However, all spoken output was severely impaired, i.e. repetition and reading of words, repetition and reading of non-words (with non-words being more severely affected), spoken naming and C9 was also unable to attempt spelling both words and non-words (suggesting impairment to APC, POL, POB, LPC, OOL, PLC and GOB and SS-to-POL pathways). She also demonstrated word-finding difficulties when naming pictures and occasionally offered semantically related words for targets (for example, target – glass, responses = drink, beer, milk then glass). C9 was unable to narrate the Cinderella story either in spoken or written formats. It was predicted that C9 would be unable to demonstrate the learning of the new vocabulary in spoken or in written form but would rely on evidencing this learning through recognition, categorisation and word-picture matching tasks.

5.14.1.4 Rehearsal and consolidation of learning

While C9 understood all instructions throughout baseline assessment and training procedures she was unable organise her learning and required guidance. To ensure that she had the same rehearsal opportunities as other participants the audio recording was played twice and guidance was provided for each practise task for each training session. Although C9 was offered the full 30 minutes for each session she used 71% of the independent learning time.

5.14.2 Demonstration of learning the new vocabulary

C9's performance on each assessment task is presented in Table 5.27 below with a summary of her ability to learn the new vocabulary for both immediate and delayed recall assessments.

5.14.2.1 Immediate recall

As Table 5.27 indicates C9 was unable to recall any of the new words either in spoken or in written form despite being given two phonemic and 17 syllable cues. She did not recognise any of the new words in either listening or reading form identifying only already familiar words. C9 did however match pictures to the correct number of syllables for ten of the words (50%) and was able to match initial syllables to their correct final syllable for nine words. She also matched three new words (listening) and five new words (reading) to their correct pictures. While C9 found it difficult to learn the new vocabulary detailed assessments indicated that she had learned some information about some of the words.

Table 5.27
C9's detailed performance on learning new vocabulary

Assessment (type)	Raw score	
	IR	DR
CR – NAME (S)	0	0
CR – NAME (W)	0	0
CR – SKILL (S/W)	0	0
CR – HABITAT (S/W)	4	5
CR – FOOD (S/W)	16	7
Recognition (L)	0	0
Recognition (R)	0	0
P-S match (P)	10	11
Syllable completion (R)	9	4

Assessment (type)	Raw score	
	IR	DR
Read aloud (R)	1	0
W-P match – NAME (L)	3	7
W-P match – NAME (R)	5	2
W-P match – SKILL (L)	7	5
W-P match – SKILL (R)	7	2
Categorisation– HABITAT/FOOD (P)	9	6
Categorisation– HABITAT/FOOD (R)	5	7
TOTAL SCORE	76	56

5.14.2.2 Delayed recall

C9 was unable to demonstrate her retention of learning though spoken or written recall despite receiving 20 syllable cues. She did, however, match the correct number of syllables for 11 new words and matched the initial syllables of four new words to their correct final syllable. C9 also matched seven new words (listening) and two new words (reading) to their correct picture.

5.14.2.3 Summary of new learning

C9 recalled 24% of information for immediate recall and 18% for delayed recall tasks, retaining 74% of originally learned information. When considering the influence of chance the data was analysed, in particular FUTARG and HAMEKIN. C9 matched FUTARG correctly to its picture for listening and reading tasks (immediate recall) and listening tasks in delayed recall. HAMEKIN was matched to the correct picture for listening and reading tasks (immediate and delayed recall) and the correct number of syllables were chosen as well as initial to final syllables, indicating new learning for these two words.

5.15 PARTICIPANT C10

Participant C10' s personal profile is presented in Table 5.28. She was widowed and lived alone with carers visiting daily and regular contact from her family. C9 presented with upper and lower hemiparesis (dominant) and mobilised with a wheelchair. This was C10's second stroke (previously 10+ years ago). She was occasionally tearful reportedly still grieving for her husband.

Table 5.28
C10's personal, medical, language and cognitive data

Personal details	
Gender	F
Age	60;02
Education (yrs)	9
Pre-morbid employment - Factory worker	
Months post-stroke	146
Stroke details – Left intra-cerebral haemorrhage	
HADs anxiety	16
HADs depression	16
Independent learning	55mins

Language screening scores	Word	N-word	
Listening lexical decision	8	7	
Repetition	8	5	
Reading lexical decision	5	7	
Read aloud	4	0	
Spelling	0.5	0	
Categorisation	15	10	12
Naming	9.5		
CLQT language	18	Severe	
Aphasia score	91	68.4%	

Cognitive sub-test scores on CLQT					Stepping-stone Route
Attention	Memory	Executive function	Visuospatial skills	Clock drawing	Non-linguistic learning
126	117	23	72	8	6
Mild	Moderate	Mild	Mild	Moderate	33%

5.15.1 Predictive factors for learning new vocabulary

The various factors for determining predictors of new learning are discussed in section 5.4.2 and are evaluated below for C10 with reference to the data in Table 5.28.

5.15.1.1 Personal attributes

C10 was aged 60;02 at the time of the investigation and was one of the oldest participants. She had spent nine years in education and was previously employed as a factory worker involving light manual work and requiring good concentration skills and the performance of accurate and speedy repetitive tasks (www.learndirect-advice.co.uk - profile 811). C10's HADs scored the highest possible 'abnormal' score indicating high emotional status for both anxiety and depression, some of which may be related to her bereavement. She was 146 months post-stroke. Due to C10's age, level of education and developed skills as well as high levels of anxiety and depression it was predicted that her personal attributes would negatively impact upon her ability to learn new vocabulary.

5.15.1.2 Cognitive abilities and the capacity to learn

The cognitive sub-tests of the CLQT indicated that C10 had mild attention, executive function and visuospatial skill impairment and moderately impaired memory and clock drawing skills. C10 demonstrated adequate visuospatial skills to engage in the training and assessment tasks by drawing detailed pictures of the creatures and copying the new words accurately. The severity of C10's memory impairment would predict a difficulty learning and recalling the new vocabulary (see section 2.6.3.3) and she also had difficulty learning the non-linguistic task only achieving 44% on immediate recall and 22% on delayed recall indicating a poor capacity to learn new information.

5.15.1.3 Severity of aphasia

The language sub-test of the CLQT suggested that C10 had severe language difficulties. Her language screening scores are displayed in Table 5.28 for each task and mapped on to a cognitive neuropsychology model in Figure 5xii below.

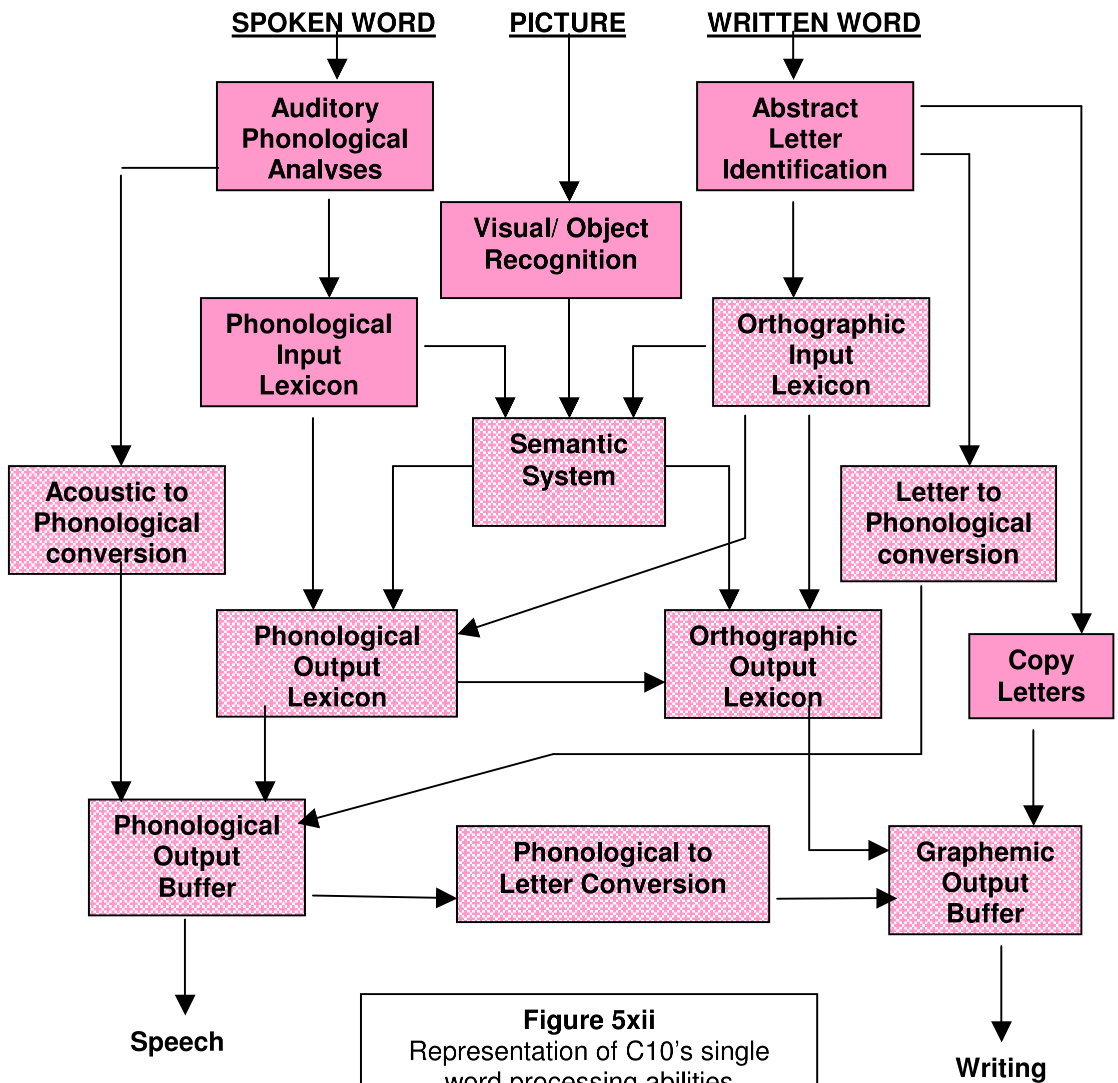


Figure 5xii
Representation of C10's single word processing abilities

The CLQT language subtest indicated that C10 had severe language impairment. C9's data (see Table 5.28 and Figure 5xii above) indicated that she had many language difficulties at single word level. C10 indicated that she could not read or spell very well prior to her stroke but the extent was unclear. She was able to speak a limited number of single words [ken, no, yes] but as can be seen by Figure 5xii with the exception of the APA, ALI, VOR and PIL all of the modules and pathways were impaired to some degree. C10 had difficulty repeating non-words, reading aloud and spelling words and non-words and also naming. C10 had some difficulties categorising pictures (67% correct) and words (80% correct). C10 was unable to narrate the Cinderella story either in spoken or in written form. Despite evidence of comprehension difficulties it was evident that C10 understood all instructions especially when given examples. It was predicted that C10 would find it difficult to demonstrate the learning of new vocabulary in any format due to her severe language impairment.

5.15.1.4 Rehearsal and consolidation of learning

Similar to C9, C10 required guidance in organising her independent learning time. She listened to the audio recording and practised some of the assessment tasks. This was required for each of the four training sessions and although C10 was offered the full 30 minutes for each session she chose to utilise 46% of the allotted independent learning time.

5.15.2 Demonstration of learning the new vocabulary

C10's performance on each assessment task is presented in Table 5.29 below with a summary of her ability to learn the new vocabulary for immediate recall assessments.

5.15.2.1 Immediate recall

C10 was unable to recall any of the new words either in spoken or written form. She was also unable to recognise the words in listening or reading recognition tasks, only responding to already familiar creatures. C10 selected the correct number of syllables for three creatures and accurately completed the written syllables for four words. C10 matched nine new words with the correct picture (listening) and eight when reading the new words. C10 did not wish to take part in the delayed recall assessment phase of the investigation.

Table 5.29
C10's detailed performance on learning new vocabulary

Assessment (type)	Raw score IR	Raw score DR	Assessment (type)	Raw score IR	Raw score DR
	IR	DR		IR	DR
CR – NAME (S)	0		Read aloud (R)	0	
CR – NAME (W)	0		W-P match – NAME (L)	9	
CR – SKILL (S/W)	0		W-P match – NAME (R)	8	
CR – HABITAT (S/W)	4		W-P match – SKILL (L)	7	
CR – FOOD (S/W)	5		W-P match – SKILL (R)	1	
Recognition (L)	0		Categorisation– HABITAT/FOOD (P)	6	
Recognition (R)	0		Categorisation– HABITAT/FOOD (R)	3	
P-S match (P)	3				
Syllable completion (R)	4		TOTAL SCORE	50	

5.15.2.2 Summary of new learning

C10 recalled 16% of information for immediate recall assessment. Consideration of the element of chance the data was analysed, in particular her performance in session two. C10 was able to match the new words with their accurate picture for all five words (both listening and reading) (MAYTOR, JUNFLIZ, PONCHINO, FEETOKEL and LUNDRIL) and for three of them she identified their skills (MAYTOR, FEETOKEL and LUNDRIL) and two of these also identified their habitat and food (MAYTOR and FEETOKEL). It is not clear why C10 demonstrated her ability to learn the new words in this particular session but had difficulty in the other three sessions as each session had identical procedures. Whatever the reason C10 demonstrated the ability for learning some of the new words despite the severity of her aphasia.

5.16 PARTICIPANT C11

Participant C11's personal profile is displayed in Table 5.30. She lived with her husband and five children. She presented with moderate residual hemiparesis (dominant hemisphere). Since her stroke C11 had been reluctant to leave her home and had just begun to attend a stroke group at the time of the investigation.

Table 5.30
C11's personal, medical, language and cognitive data

Personal details	
Gender	F
Age	45;03
Education (yrs)	15
Pre-morbid employment - bookbinder	
Months post-stroke	23
Stroke details -Left middle cerebral artery aneurism (multiple)	
HADs anxiety	12
HADs depression	5
Independent learning	60mins

<table>
<tr><th>Language screening scores</th><th colspan="2">Word</th><th colspan="2">N-word</th></tr>
<tr><td>Listening lexical decision</td><td colspan="2">6</td><td colspan="2">5</td></tr>
<tr><td>Repetition</td><td colspan="2">0</td><td colspan="2">0</td></tr>
<tr><td>Reading lexical decision</td><td colspan="2">6</td><td colspan="2">8</td></tr>
<tr><td>Read aloud</td><td colspan="2">0</td><td colspan="2">0</td></tr>
<tr><td>Spelling</td><td colspan="2">0</td><td colspan="2">0</td></tr>
<tr><td>Categorisation</td><td>15</td><td colspan="2">15</td><td>13</td></tr>
<tr><td>Naming</td><td colspan="4">0</td></tr>
<tr><td>CLQT language</td><td colspan="2">1</td><td colspan="2">Severe</td></tr>
<tr><td>Aphasia score</td><td colspan="2">68</td><td colspan="2">51%</td></tr>
</table>

Cognitive sub-test scores on CLQT					Stepping-stone Route
Attention	Memory	Executive function	Visuospatial skills	Clock drawing	Non-linguistic learning
124	56	6	41	1	0
Moderate	Severe	Severe	Severe	Severe	0%

5.16.1 Predictive factors for learning new vocabulary

The various factors for determining predictors of new learning are discussed in section 5.4.2 and are evaluated below for C11 with reference to the data in Table 5.30.

5.16.1.1 Personal attributes

C11 was aged 45;03 at the time of the investigation and was one of the younger participants. She had spent 15 years in education and was previously employed as a bookbinder, which required the ability to be quick to learn new skills and be able to measure and count accurately (www.learndirect-advice.co.uk - profile 576). C11's HADs scored 'abnormal' for anxiety and 'normal' for depression and she was 23 months post-stroke. C11's husband had advised that she had recently been treated for clinical depression but was no longer on medication. Due to C11's age, level of education and developed skills it was predicted that her personal profile would have a positive impact on her ability to learn new words, however, there may be negative influence from her high anxiety status.

5.16.1.2 Cognitive abilities and the capacity to learn

The cognitive sub-tests of the CLQT indicated that C11 had moderate attention impairment and her memory, executive function, visuospatial skills and clock drawing skills were severely impaired. C11 demonstrated adequate visuospatial skills to engage in the training and assessment tasks by drawing detailed pictures of the creatures and copying the new words accurately. The severity of C11's cognitive impairments would predict difficulty in learning and recalling the new vocabulary (see section 2.6.3.3) and although attempted she did not achieve any score on the non-linguistic learning task despite numerous instructions and demonstrations, indicating a poor general capacity to learn.

5.16.1.3 Severity of aphasia

The language sub-test of the CLQT suggested that C11 had severe language difficulties. Her language screening scores are displayed in Table 5.28 for each task and mapped on to a cognitive neuropsychology model in Figure 5xiii below. The CLQT language subtest indicated that C11 had severe language impairment. C11's data (see Table 5.30 and Figure 5xiii below) indicated that she had many language difficulties at single word level.

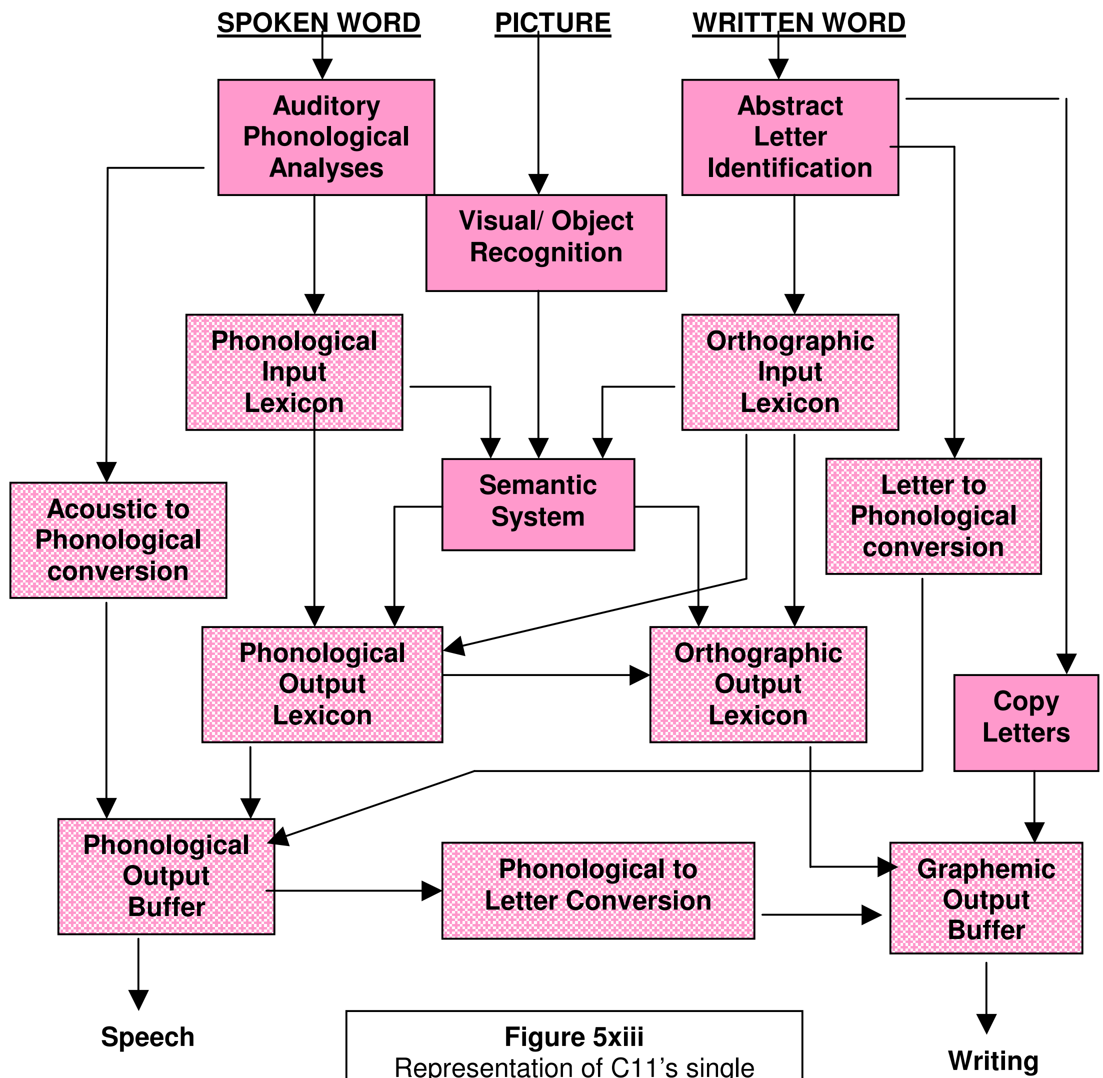


Figure 5xiii
Representation of C11's single word processing abilities

C11's performance on the categorisation task indicates that she was able to access her semantic system for meaning. She could also copy words accurately. However as can be seen by Figure 5xiii above, apart from APA, ALI, VOR, SS and COPY LETTERS, many of the modules and pathways were impaired. C11 was unable to repeat, read aloud or spell any words or non-words. Her husband advised that C11 had some reading and spelling difficulties prior to her stroke. C11 was also unable to name any pictures and her speech was unintelligible consisting mainly of vowel-like sounds and soft-contact plosives. C11 was unable to narrate the Cinderella story either in spoken or in written form. Despite comprehension difficulties it was evident that C11 understood all instructions especially when given demonstration. It was predicted that C11 would find it difficult to demonstrate the learning of new vocabulary due to her severe language impairment.

5.16.1.4 Rehearsal and consolidation of learning

Similar to C9 and C10, C11 required guidance organising her independent learning time. She listened to the audio recording and practised some of the assessment tasks. This was required for each of the four training sessions and although C11 was offered the full 30 minutes for each session she chose to utilise 50% of the allotted independent learning time.

5.16.2 Demonstration of learning the new vocabulary

C11's performance on each assessment task is presented in Table 5.31 below with a summary of her ability to learn the new vocabulary for immediate recall assessments.

5.16.2.1 Immediate recall

C11 was unable to recall any of the 20 new words either in spoken or in written form. Due to unintelligible speech she did not read aloud. She recognised nine words for listening tasks and three words for the reading recognition tasks but had five false positive and one false negative response. C11 also had three false negative and five false positive responses for the baseline results. C11 was able to match one word (listening) and eight words (reading) to the correct pictures. She also matched eight new words to their correct syllable number and matched initial syllables for four words to their correct final syllable. C11 did not wish to take part in the delayed recall assessment phase.

Table 5.31
C11's detailed performance on learning new vocabulary

Assessment (type)	Raw score	
	IR	DR
CR – NAME (S)	0	
CR – NAME (W)	0	
CR – SKILL (S/W)	0	
CR – HABITAT (S/W)	0	
CR – FOOD (S/W)	0	
Recognition (L)	9	
Recognition (R)	3	
P-S match (P)	8	
Syllable completion (R)	4	

Assessment (type)	Raw score	
	IR	DR
Read aloud (R)	0	
W-P match – NAME (L)	1	
W-P match – NAME (R)	8	
W-P match – SKILL (L)	3	
W-P match – SKILL (R)	4	
Categorisation– HABITAT/FOOD (P)	5	
Categorisation– HABITAT/FOOD (R)	4	
TOTAL SCORE	49	

5.16.2.2 Summary of new learning

C11 recalled 15% of information for immediate recall assessments. As with participants C9 and C10 the element of chance was considered with such a low performance score. Three words in particular suggested that they were learned rather than the result of random choice – LUNDRIL, SARTLE AND TRAIGOL. C11 matched the new words LUNDRIL and SARTLE to the correct picture for both listening and reading tasks and matched LUNDRIL's initial syllable with its correct final syllable. C11 also matched the new word TRAIGOL with its picture for the reading task and its skill for listening and reading modalities as well as its habitat and food for the reading task. This suggests that C11 was able to demonstrate that she had learned some of the new vocabulary despite severe language impairment.

5.17 SUMMARY

The first part of this chapter reported findings that established that people with aphasia were able to learn new vocabulary despite differing levels of severity of aphasia. All twelve participants took part in the four training and immediate recall sessions. The abilities of participants to demonstrate learning of the new vocabulary varied from learning all 20 new words to no new words for cold recall assessments (both spoken and written). Due to the nature of aphasia some participants were unable to demonstrate their learning in spoken and /or written form. However, the various assessments based on the cognitive neuropsychology approach facilitated the demonstration of this learning in ways other than spoken or written recall and provided evidence that every participant learned some of the new vocabulary. Learning abilities ranged from 15% to 99% of information learned about the new words for immediate recall tasks (i.e. raw score total of 49 to 318 from a total maximum score of 320 with the exception of P3 whose maximum score was 280). These assessment tasks were repeated three to five days following the final training session to measure the extent of information that was retained in long-term memory (delayed recall). Ten participants partook in delayed recall assessments (C10 and C11 declined) and performance indicated that retention of original information learned ranged from 49% to 83% (i.e. raw score total of 56 to 263.5 from a total maximum score of 320 with the exception of P3 whose maximum possible score was 280).

The profiles of the 12 participants were then presented individually. As can be seen in the preceding personal profile tables (see sections 5.5 to 5.16), there was a broad range of age, educational and employment experience among participants. Furthermore, there was a wide variety of severity of aphasia and a range of language abilities. The cognitive abilities and emotional status of participants also varied considerably. Predictions were made regarding the positive and negative impact of various factors on the ability of participants to learn the new vocabulary based on the literature. However, there were many influencing factors (for example, age, education, emotional and cognitive status) and with the exception of the severity of aphasia it was difficult to objectively identify which of these factors impacted upon the ability to learn and to what degree. The severity of aphasia appeared to negatively impact upon assessment performance. Participants who were unable to speak or write were unable to complete tasks that required spoken or written responses, appearing to place them at a disadvantage compared to more verbal participants. Table 5.2 (see section 5.3) presents participant scores obtained from all tasks not requiring spoken and written responses. The ranking of C1, C5, C8, C9, C10, C11 remained the same despite C9-C11 having the most severe language impairment of the 12 participants. The scores of participants whose ranking changed as a result of the removal of spoken and written assessment scores only varied by 2-6%. Therefore, the original immediate recall total (i.e. including spoken and written tasks) was considered reflective of the overall ability to learn the new vocabulary by participants. As the severity of aphasia did not explain the wide variation in participant performance in demonstrating the new learning it was important to evaluate other factors in an attempt to explain this variation. It was decided to evaluate if those factors considered to impact upon recovery from aphasia also impacted upon the ability to learn new vocabulary.

The next section of this chapter examines the total raw scores from participants' immediate recall performance in order to observe if particular clusters or groups of participants emerge who learned the new vocabulary equally as well as each other. If so, hypotheses will be formed to evaluate the possible variables that divide these groups of participants (e.g. personal attributes, cognitive abilities and severity of aphasia). The tasks and stimuli that were employed in the main investigation were also appraised in terms of their contribution to the scores. Reliability between the four learning sessions is also recorded.

5.18 FACTORS AFFECTING THE LEARNING OF NEW VOCABULARY

As discussed above, various factors were considered likely to have affected the learning of new vocabulary by the participants with aphasia. An exploratory statistical method was chosen to identify groups of participants who exhibited similar characteristics related to these potentially influencing factors. The immediate recall scores of participants were initially chosen for this analysis as these scores reflected the learning performance of each individual (whereas the delayed recall scores reflected the retention of newly learned vocabulary). As individual cluster groups were not pre-determined and the data sample was less than 200 a hierarchical cluster analysis was applied to the group results for total immediate recall raw scores (see Table 5.1). Following this, hierarchical cluster analyses were conducted for all variable factors (personal attributes, cognitive abilities, severity of aphasia and non-linguistic learning). This data was evaluated to ascertain how variables clustered participants into particular groups. The findings are discussed in relation to the learning of new vocabulary by the aphasic participants.

Following these analyses, hypotheses were formed in consideration of the literature and the various performances of participants. These hypotheses were then tested with the aim of forming predictions regarding the ability of individuals in the wider population of people with aphasia to learn new vocabulary. Each hypothesis was tested using quantitative correlation statistics as well as qualitative observations. The normality of the data was assessed and twelve of the data sets were found to have normal distributions. Two factors (non-linguistic learning and executive function) were skewed and were not normally distributed. However, as most parametric tests are reasonably robust, they can tolerate a certain amount of deviation from parametric assumptions. Therefore, it was considered that parametric assumptions were largely satisfied and a Pearson correlation coefficient was chosen to test the hypotheses (see section 5.18.2). These hypotheses were evaluated by correlating the data from Table 5.1 with each participant's relevant data, i.e. personal attributes, cognitive abilities, severity of aphasia and learning strategies, for both the immediate and delayed recall assessments. Tasks and stimuli are also evaluated and the inter-session reliability is noted.

5.18.1 Hierarchical cluster analyses

As described in 5.18, a hierarchical cluster analysis was performed for the total raw scores of all participants (immediate recall) using SPSS for Windows (2003) programme to ascertain if groups of participants with similar scores emerged. Following this, hierarchical cluster analyses were performed to discover whether participants who were grouped together for learning performance also clustered together for other attributes, i.e. amount of newly learned information retained (i.e. delayed recall), age, years in education, emotional status, cognitive abilities, severity of aphasia and learning strategies).

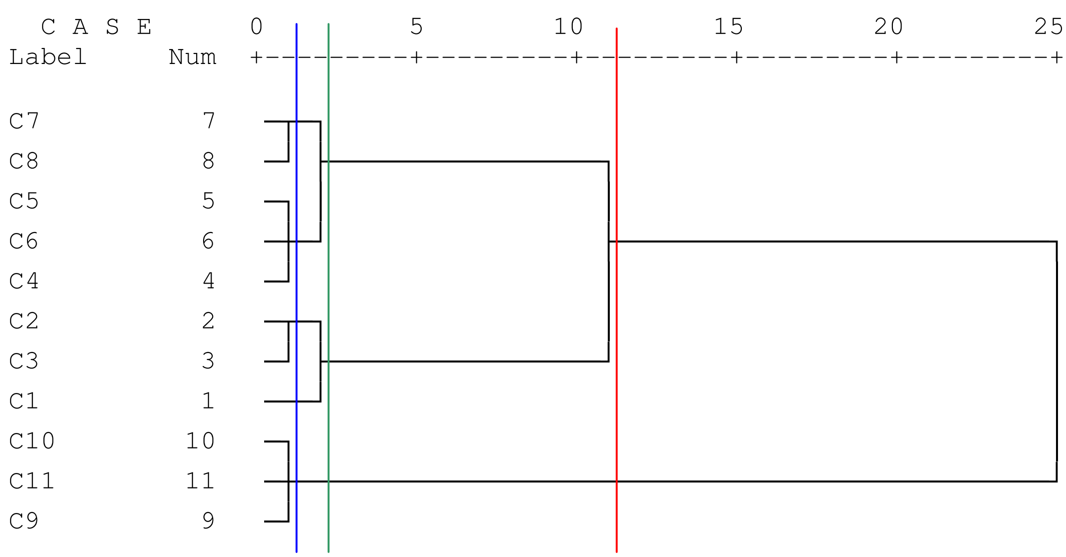


Figure 5xiv
Hierarchical cluster analysis
Dendrogram using Average Linkage (Between Groups)

It is clear from the dendrogram in Figure 5xiv above that the interpretation of which clusters are formed is subjective. For example, groups could be formed using the red line, which would create two clusters, C10, C11 and C9 forming one group, and all other participants forming another. Similarly, the green line could form yet another set of clusters. However, the groups indicated by the blue line were chosen for this investigation since the closer a group is to zero, the more similar the members of the group are, therefore, these groups suggest more similar abilities and attributes than other group choices.

Table 5.32 below presents the five participant clusters that emerged from the hierarchical cluster analysis using immediate recall scores (See Appendix 5.4a). In the top row, the initial clusters formed by applying the immediate recall learning scores of participants to the cluster analysis (representing the learning ability of each participant) (See Appendix 5.4a). As can be seen in Table 5.32 there was only one participant (C1) in Cluster 1. She achieved the highest score of all 12 main investigation participants. Cluster 2 contained participants C2 and C3 as they achieved similar scores. Cluster 3 contained three participants (C4, C5 and C6). Participants C7 and C8 formed Cluster 4 and the fifth cluster contained C9, C10 and C11 who were the three lowest scoring participants. The various other factors that were examined using cluster analysis are also presented and the individual dendrograms for each factor are presented in Appendix 5.4. In order to make comparisons, each member is presented in Table 5.32 in the column of their respective immediate recall cluster (for example, C1 is always presented in Cluster 1, C11 always in Cluster 5). The objective of this analysis was to identify what factors participants who were clustered together, as a result of similar learning levels (immediate recall scores), also had in common, in order to ascertain if particular factors could be attributed to be shown to impact upon participant learning ability.

Table 5.32
Hierarchical cluster analyses
Comparison of various clusters with initial immediate recall score groupings

Variables	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Immediate recall clusters	**C1 (318)**	**C2 (284)** **C3 (266)**	**C4 (215)** **C5 (199)** **C6 (189.5)**	**C7 (155)** **C8 (154.5)**	**C9 (76)** **C10 (50)** **C11 (49)**
Delayed recall	**C1** (263.5)	**C2** (188) **C3** (210.5)	**C4** (144) **C5** (159) **C6** (132)	**C7** (110.5) **C8** (102)	**C9** (56)
Age (months)	**C1** (473)	**C2** (407) **C3** (651)	**C4** (515) **C5** (675) **C6** (682)	**C7** (615) **C8** (668)	**C9** (691) **C10** (722) **C11** (543)
Education (years)	**C1** (21.5)	**C2** (17) **C3** (13)	**C4** (14) **C5** (13) **C6** (13)	**C7** (12) **C8** (11)	**C9** (11) **C10** (9) **C11** (15)
Months post-stroke	**C1** (66)	**C2** (39) **C3** (96)	**C4** (13) **C5** (20) **C6** (13)	**C7** (29) **C8** (5)	**C9** (114) **C10** (146) **C11** (23)
HADs rating anxiety	**C1** (6)	**C2** (4) **C3** (10)	**C4** (1) **C5** (6) **C6** (16)	**C7** (5) **C8** (5)	**C10** (16) **C9** (14) **C11** (12)
HADs rating depression	**C1** (4)	**C2** (4) **C3** (1)	**C4** (1) **C5** (10) **C6** (10)	**C7** (4) **C8** (3)	**C9** (10) **C10** (16) **C11** (5)
Severity of aphasia	**C1** (124)	**C2** (99.5) **C3** (124.5)	**C4** (120) **C5** (127.5) **C6** (119.5)	**C7** (97) **C8** (99)	**C11** (68) **C9** (89) **C10** (91)
Attention	**C1** (203)	**C2** (197) **C3** (185)	**C4** (122) **C5** (148) **C6** (184)	**C7** (180) **C8** (195)	**C9** (60) **C10** (126) **C11** (124)
Memory	**C1** (163)	**C2** (129) **C3** (133)	**C4** (128) **C5** (129) **C6** (133)	**C7** (101) **C8** (114)	**C9** (74) **C10** (117) **C11** (56)
Executive functions	**C1** (30)	**C2** (30) **C3** (24)	**C4** (25) **C5** (20) **C6** (28)	**C7** (25) **C8** (26)	**C9** (17) **C10** (23) **C11** (6)
Visuospatial skills	**C1** (99)	**C2** (103) **C3** (88)	**C5** (93) **C4** (79) **C6** (82)	**C7** (94) **C8** (99)	**C10** (72) **C9** (50) **C11** (41)
Clock drawing skills	**C1** (12)	**C2** (13) **C3** (13)	**C4** (10) **C5** (0) **C6** (7)	**C7** (12) **C8** (10)	**C10** (8) **C9** (0) **C11** (1)
Non-linguistic route	**C1** (18)	**C2** (18) **C3** (18)	**C4** (18) **C5** (13) **C6** (14)	**C7** (17) **C8** (18)	**C9** (18) **C10** (6) **C11** (0)

(n) = total raw score data
Green shading = grouped together as in immediate recall clusters
Grey shading = original clusters not formed

The green shading in Table 5.32 indicates where participants have common factors in respect of their learning ability (although not necessarily the only members of a particular grouping). For example, when participants were clustered according to delayed recall scores it was revealed that the same cluster groupings emerged as the original ones, i.e. C2 and C3 had similar original learning scores and also retained similar amounts in long-term memory. Although C10 and C11 did not participate in delayed recall tasks it was shown that C9 was still clustered alone suggesting the same pattern for Cluster 5. The severity of aphasia factor indicates that Cluster 3 and Cluster 4 participants also had similar levels of language severity, whereas only C9 and C10 clustered together for this factor and Clusters 1 and 2 did not retain their original groupings for that factor. The grey shading indicates that the originally formed clusters (i.e. immediate recall clusters) were not grouped together for particular factors (but were present within other groups). For example, C4, C5 and C6 had similar immediate recall scores therefore they were grouped together in Cluster 3. However, only two members of that cluster, C5 and C6, were of a similar age (aged 56;3 and 56;10 months respectively) so they grouped together (green shading). However C4, the other member of Cluster 3 was aged 42;11 which was closer to C11 in age who was aged 45;03, therefore they were clustered together rather than with their original cluster members (grey shading).

The cluster analyses above presents C1 as remaining in a cluster alone for age, education and months post-stroke. These were the only factors that distinguished her from the other participants (apart from her learning scores). For all other variables C1 appeared within other groups. The participants in Cluster 2, C2 and C3, grouped together for cognitive abilities, in particular, they had very similar scores for attention, memory, visuospatial skills and non-linguistic route learning. C5 and C6 from Cluster 3 grouped together for age, number of years educated, depression rating, visuospatial skills and ability to learn the non-linguistic route. All three members of Cluster 3 grouped together for months post-stroke, severity of aphasia and memory. The more frequent grouping of C5 and C6 suggests that they shared more characteristics than C4. Cluster 4 appeared to be a strong cluster where participants grouped for all factors with the exception of age, memory, visuospatial skills and clock drawing skills. The final cluster (five) appeared to be the least coherent of the groups as the participants tended to group together as two rather than three group members at a time with participant C9 being the common participant for all but one of the group's variables.

While the power of the cluster analyses above is not strong it enables qualitative observations and comparisons about the learning behaviour of the participants and their similarities and difference in characteristics and abilities. The factors that tended to fall into groups that reflected the groupings for learning performance were months post-stroke, severity of aphasia, attention, visuospatial skills and the ability to learn the non-linguistic route task. There were a number of factors that did not group people in their original clusters, in particular, executive functions and clock drawing skills. However, no one factor appeared to relate directly to learning ability alone. Quantitative statistical correlations were then used to test hypotheses, derived from the literature and participant learning performance, relating to the factors that were considered to affect the ability of people with aphasia to learn the new vocabulary. P3 was included in the data used to test the first hypothesis (see section 5.5), however, as he did not take part in two tasks for the immediate recall assessment (see section 4.6.3), his performance was not included in the group statistics.

5.18.2 Statistical correlations between learning performance and various participant factors

Significance of correlations between the variables highlighted above (see section 5.18.1) is now explored. The variables to be considered are divided into the following categories; personal attributes (see section 5.4.2.1), cognitive abilities (see section 5.4.2.2), language ability (see section 5.4.2.3) and learning strategies (see section 5.4.2.4). The contribution of the methodology to the scores of participants will also be noted i.e. stimuli and task (see section 5.18).

5.18.2.1 Personal attributes

The variables that were considered under the heading of 'personal attributes' include age of participants, number of years in education, HADs anxiety and depression self-rating and number of months post-stroke. The following hypotheses were tested by the statistical analysis:

Hypothesis two	Age correlates negatively with the recall of new vocabulary therefore older participants will learn less new vocabulary than younger ones (see section 2.6.1.1).
Hypothesis three	The number of years in education correlates positively with the recall of new vocabulary therefore participants with more years education will learn more new vocabulary than those with less educational experience (see section 2.6.1.2).
Hypothesis four	The number of months post-stroke correlates positively with the recall of new vocabulary therefore participants who are longer post-stroke will learn more vocabulary than those who are earlier post-stroke (see section 5.4.2)
Hypothesis five	A self-rating of anxiety correlates negatively with the recall of new vocabulary therefore more anxious participants will learn less new vocabulary than those without anxiety (see section 2.6.3.2).
Hypothesis six	A self-rating of depression correlates negatively with the recall of new vocabulary therefore participants experiencing depression will learn less new vocabulary than those without depression (see section 2.6.3.2)

Table 5.33
Correlation co-efficients: IR~ personal attributes of 11 participants
(Pearson Correlation results using 1-tailed significance)

Variables	Results	Outliers
Age	r = -.755; p<.01	C11
Education	r = +.869; p<.01	C11
Months post-stroke	r = +.629; p<.05	C3, C9, C10
HADs Anxiety rating	r = -.672; p<.05	C6
HADs Depression rating	r = -.562; p<.05	--------

The correlation statistics displayed in Table 5.33 indicate that all of the above five hypotheses were supported in relation to immediate recall. Participant C11 was an outlier for two variables and was also the person who achieved the lowest performance score of 15%. There were three outliers for months post-stroke – C3, C9, and C10. C6 had a high anxiety rating but was also able to perform well on the tasks. The two strongest correlations according to ranking were age (r=-.755) and education (r=+.869).

Table 5.34
Correlation co-efficients: DR~ personal attributes of 10 participants
(Pearson Correlation results using 1-tailed significance)

Variables	Results	Outliers
Age	r = -.597; p<.05	--------------
Education	r = +.847; p<.01	--------------
Months post-stroke	r = +.895; p<.01	C3, C9
HADs Anxiety rating	r = -.274; p=.237	--------------
HADs Depression rating	r = -.400; p=.143	----------------

The analyses of the hypotheses in relation to delayed recall performance are presented in Table 5.34. The hypotheses relating to age, number of years in education and months post-stroke are supported but both anxiety and depression self-rating are not correlated with the delayed recall of the learned vocabulary. There were two outliers, C3 and C9, for months post-stroke. The two strongest correlations according to ranking were education (r=+.847) and months post-stroke (r=+.895).

5.18.2.2 Cognitive abilities

The variables considered in this category are attention, memory, executive functions, visuospatial skills, non-linguistic learning and clock drawing skills. The following hypotheses were tested:

Hypothesis seven	Attention correlates positively with the recall of new vocabulary therefore participants with attention impairment will learn less new vocabulary than those without attention difficulties (see section 2.6.3.3).
Hypothesis eight	Memory correlates positively with the recall of new vocabulary therefore participants with memory impairment will learn less new vocabulary than those without memory impairment (see section 2.6.3.3).
Hypothesis nine	Executive functions correlate positively with the recall of new vocabulary therefore participants with executive function impairment will learn less new vocabulary than those without executive dysfunction (see section 2.6.3.3).
Hypothesis ten	Non-linguistic learning correlates positively with the recall of new vocabulary therefore participants who had difficulty learning the non-linguistic task will also have difficulty learning new vocabulary (see section 4.2.2.2).
Hypothesis eleven	Clock drawing skills correlate positively with the recall of new vocabulary therefore participants with impaired clock drawing skills will have more difficulty learning new vocabulary than those who had good clock drawing skills (see section 4.2.2.2).

Table 5.35
Correlation co-efficients: IR~ cognitive screening scores of 11 participants (Pearson Correlation results using 1-tailed significance)

Variables	Results	Outliers
Attention	r = +.821; p<.01	C4, C9
Memory	r = +.935; p<.01	C10
Executive functions	r = +.670; p<.05	C11
Non-linguistic learning	r = +.132; p=.367	C10, C11
Clock drawing skills	r = +.774; p<.01	C5

As can be seen for the immediate recall analyses in Table 5.35, hypotheses seven to eleven were supported with the exception of hypothesis ten, which suggests that non-linguistic learning does not correlate with the learning of new vocabulary. The two strongest correlations according to ranking were memory (r=+.935) and attention (r=+.821).

Table 5.36
Correlation co-efficients: DR~ cognitive screening scores of 10 participants (Pearson Correlation results using 1-tailed significance)

Variables	Results	Outliers
Attention	r = +.615; p<.05	---------------
Memory	r = +.905; p<.01	---------------
Executive functions	r = +.603; p<.05	---------------
Non-linguistic learning	r = +.085; p=.414	---------------
Clock drawing skills	r = +.706; p<.05	C5

Table 5.36 depicts the correlation analyses of cognitive abilities and the delayed recall scores. It indicates that the cognitive domains of attention, memory, executive function and clock drawing skills correlated significantly with delayed recall whereas non-linguistic learning was not. The two strongest correlations according to ranking were memory (r=+.905) and clock drawing skills (r=+.706).

5.18.2.3 Language ability

There were two variables in this category. The first being the score obtained from a language screening test (severity of aphasia) and the other from the language section of the Cognitive Linguistic Quick Test (Helm-Estabrooks, 2001).

Hypothesis twelve	Severity of aphasia positively correlates with the recall of new vocabulary therefore, participants with severe aphasia will learn less new vocabulary than those with less severe aphasia (see section 5.4.2.3).

Table 5.37
Correlation co-efficients: IR~ aphasia screening scores of 11 participants
(Pearson Correlation results using 1-tailed significance)

Variables	Results	Outliers
Severity of Aphasia	r = +.769; p<.01	------------
CLQT language	r = +.602; p<.05	C11

Both the severity of aphasia score from the language screening assessments and the language sub-test from the CLQT were correlated with the ability to learn new vocabulary as assessed by both immediate recall (see Table 5.37) and delayed recall (see Table 5.38) scores. Thus hypothesis twelve above was supported.

Table 5.38
Correlation co-efficients: DR~ aphasia screening scores of 10 participants
(Pearson Correlation results using 1-tailed significance)

Variables	Results	Outliers
Severity of Aphasia	r =+.680; p<.05	----------------
CLQT language	r = +.741; p<.05	----------------

5.18.2.4 Learning strategies

The variable in this category was the ‘independent learning time’ used by the participants to consolidate their learning.

Hypothesis thirteen	Independent learning time is positively correlated with the recall of new vocabulary therefore participants who rehearse and consolidate their learning for longer would learn more new vocabulary than those who take less time (see section 2.8.5.3).

Table 5.39
Correlation co-efficients: IR~ independent learning time of 11 participants
(Pearson Correlation results using 1-tailed significance)

Variables	Results	Outliers
Independent learning time	r = +.890; p<.01	C7

Tables 5.39 and 5.40 indicate that the independent learning time taken by participants correlated with the success in learning the new vocabulary as assessed by both immediate and delayed recall of the words. Participant C7 was an outlier for both analyses.

Table 5.40
Correlation co-efficients: DR~ independent learning time of 10 participants
(Pearson Correlation results using 1-tailed significance)

Variables	Results	Outliers
Independent learning time	r = +.756; p<.05	C7

5.18.3 Aspects of the methodology in relation to participant performance

5.18.3.1 Reliability of learning performance

This section evaluates the reliability of performance across the four training sessions and comments on some aspects of the stimuli and task characteristics in relation to participant performance.

Table 5.41
Correlation co-efficients: IR~ reliability of performance for each training session of11 participants
(Pearson Correlation results using 2-tailed significance)

Variables	Results
Session 1 and Session 2	r = +.965; p<.01
Session 1 and Session 3	r = +.955; p<.01
Session 1 and Session 4	r = +.961; p<.01
Session 2 and Session 3	r = +.960; p<.01
Session 2 and Session 4	r = +.923; p<.01
Session 3 and Session 4	r = +.930; p<.01

Table 5.42
Correlation co-efficients: DR~ reliability of performance for each training session of 10 participants (Pearson Correlation results using 2-tailed significance)

Variables	Results
Session 1 and Session 2	r = +.804; p<.01
Session 1 and Session 3	r = +.746; p<.05
Session 1 and Session 4	r = +.734; p<.05
Session 2 and Session 3	r = +.905; p<.01
Session 2 and Session 4	r = +.852; p<.01
Session 3 and Session 4	r = +.965; p<.01

The results from all four sessions positively correlate with each other for immediate recall (see Table 5.41) and delayed recall (see Table 5.42) assessments indicating that participants found the stimuli in each session equally challenging to learn. It also suggests that the anxiety and depression levels were not affected by getting more or less comfortable with each session.

5.18.3.2 Learning performance in relation to individual stimuli

The number of times the new words were recalled, in both immediate and delayed recall assessments, are presented in Appendix 5.6 in descending order, along with the session number in which they were trained. The new word that was recalled the most successfully during the immediate recall assessments was 'FUTARG' – the first word presented in session one (recalled 134 times throughout various assessment tasks). The second most frequently recalled new word was ' CURVOL'– presented in session four (recalled 128 times). The two new words that appeared most difficult to learn were 'SILVARK' – presented in session three (recalled 108 times throughout various assessment tasks) and 'JUNFLIZ'– presented in session two (recalled 106.5 times). The delayed recall assessments revealed that participants were best able to recall ZOODOP and SILVARK – SILVARK being one of the least recalled words in immediate recall assessments. (both recalled 86 times). Participants found 'LUNDRIL'– trained in session two (recalled 65 times) and 'HAMEKIN'– trained in session three (recalled 60.5 times) the most difficult details to recall. The new words most recalled were from sessions one and four, suggesting perhaps a recency and primacy effect, however, as Appendix 5.6 indicates the words most easily recalled and the ones which appeared most difficult to recall were spread throughout the four sessions, indicating that there were no recency or primacy effects in the immediate or delayed recall of the new words.

5.18.3.3 Learning performance in relation to learning assessment tasks

The various assessment tasks are listed in Appendix 5.7 in descending order beginning with those tasks at which participants performed most successful. The easiest assessments for participants to correctly perform appeared to be the listening and reading recognition of the new words and the syllable completion tasks, both for immediate and delayed assessment tasks. These tasks did not require spoken or written output by participants and the provision of the new words or part of the new words may have facilitated access of the correct information. These tasks are thought to involve the phonological and orthographic input lexicons and phonological output lexicon from the cognitive neuropsychology model. The most difficult tasks appeared to be recalling the spoken naming and skills of the new words for both immediate and delayed recall. Participants with severe aphasia would not have been able to score highly on spoken naming tasks by the very nature of their language impairment. To demonstrate learning through this task, participants would have had to access their semantic system, the pathway from semantics to phonological output lexicon, phonological output lexicon and phonological output buffer according to the cognitive neuropsychological model. Participants with impairments throughout this pathway would not have scored well on this task. As participants could have recalled the skills either in spoken or written form, even those participants with severe spoken aphasia could have demonstrated this learning in written form. According to the cognitive neuropsychology framework there were two optional pathways, including that for the naming task described above and also where this pathway diverges from the phonological output lexicon to the orthographic output lexicon and graphemic output buffer.

Therefore it appears that the recall of skills was one of the most difficult tasks for participants to perform. However, as these tasks were similar to those involved in the recall of the new vocabulary, it suggests that participants found the skills most difficult to learn. Overall as might have been anticipated, the easiest tasks for participants to demonstrate learning (immediate recall) were those tasks that did not require spoken or written output, i.e. recognition, completion and word-picture matching tasks. Conversely, the most difficult tasks to facilitate the demonstration of learning appeared to be those that required spoken or written output, i.e. spoken and written naming and reading aloud suggesting a direct relation to the severity of aphasia. This was also reflected in the demonstration of retained learning of the new words in delayed recall assessment tasks.

5.19 CHAPTER SUMMARY

The recruitment criteria and procedure for participants for the main investigation were presented in this chapter as well as a brief summary of the training and assessment procedure (see section 5.2). The main investigation results were then reported. These results have established that people with aphasia can learn new vocabulary despite the presence of aphasia. This ability was then compared and contrasted qualitatively with the normal population (see section 5.3.1). A case series presented the personal profiles of all participants individually and demonstrated their individual abilities to learn the new words (see section 5.4). This data indicated a wide range of background, ability and impairments within this aphasic population which was reflected in the variation in their learning performance. Factors considered to affect the learning of new vocabulary were then investigated using hierarchical cluster analysis and statistical correlations. These factors included personal attributes (i.e. age, years in education, months post-stroke, anxiety and depression ratings), cognitive abilities (i.e. attention, memory, executive functions, visuospatial skills, clock drawing skills and the ability to learn a non-linguistic task) and the severity of aphasia. The findings indicated significant correlations between learning ability and these factors (with the exception of non-linguistic learning). The stimuli and tasks used in the training and assessment procedures were evaluated identifying the new words and tasks which participants found the easiest and most challenging to learn. The next chapter will interpret these findings and discuss them in relation to the literature and its contribution to the theory of rehabilitation.

Chapter 6 Discussion of findings

6.1 INTRODUCTION

Not everyone with aphasia recovers to the same degree and many people retain residual language impairments to varying degrees of severity (see section 2.4.1). While there are theories and models of language impairment such as the cognitive neuropsychology approach (see section 2.9.3), currently there is no model or theory of rehabilitation that explains what therapy is or describes the process(es) involved in the restoration of the damaged language system (see section 2.7). Therefore it is not possible to discern what approaches or tasks in aphasia rehabilitation would be most successful at restoring particular language functions. Such a model or theoretical account would identify the process of therapeutic rehabilitation and highlight any constraints to the restitution of language impairment. Additionally, it would identify those most likely to benefit from language rehabilitation, thereby allowing more targeted allocation of limited resources.

The development of a theory of rehabilitation would be a considerable undertaking. A first step however would be to ascertain if therapeutic interventions facilitate the accessing of previously known information rendered inaccessible due to the impact of the stroke. It has been demonstrated that cortical plasticity occurs during the learning process (see section 2.5.2) and has also been observed during language rehabilitation (see section 2.5.5). Therefore, the rehabilitation of aphasia could involve the process of new learning, resulting in the creation of new neuronal connections for vocabulary newly acquired (or re-acquired) during the therapeutic process. The two processes (re-accessing information and laying down new representations through learning) could also be occurring in tandem. Perhaps old memory traces are re-accessed where possible and where cortical damage is too great for restitution of particular neuronal patterns, a process of new learning might occur with the creation of new neuronal connections. A review of the literature indicated that while a small number of studies have investigated the potential of domain-specific new learning (i.e. in the language domain) by people with aphasia, the stimuli employed by these studies involved already familiar word forms or meanings (see section 2.8.5.3) and no study had employed unfamiliar word forms paired with unfamiliar word meanings i.e. new vocabulary. Therefore, the acquisition of new vocabulary by people with aphasia had not yet been adequately investigated. So the question of whether new learning in the language domain occurs during the rehabilitation process of language restitution remained unanswered. This investigation addressed this research question and explored the ability of young adults (<65 years) to learn new vocabulary despite the presence of post-stroke aphasia. A discussion of the key findings of the main investigation is presented in this chapter (see section 6.2) as well as an analysis of the characteristics of participant learning. Factors affecting the learning of new vocabulary are discussed (see section 6.3). Participant criteria, recruitment and participation in the main investigation (see section 6.4.1), and the development of the novel stimuli and methodology employed (see section 6.4.2) are also discussed in this chapter. The effectiveness of the cognitive neuropsychology model in supporting the main investigation, and its usefulness as a tool in learning studies is discussed (see section 6.5). A reflection on the theoretical and clinical relevance of the findings (see section 6.6), an evaluation of the investigation (see section 6.7) and suggestions for future research (see section 6.8) complete this thesis.

6.2 DISCUSSION OF FINDINGS IN RELATION TO THE MAIN RESEARCH QUESTION

The main investigation has established that people with aphasia can learn new vocabulary despite residual language impairment. All twelve participants demonstrated some ability to learn the new vocabulary and performance varied from the highest recall score of 99% (i.e. raw score of 318 from a possible maximum total of 320) to the lowest of 15% (i.e. raw score of 49 from a possible maximum total of 320). Qualitative analysis of the data indicated that low scoring participants had learned a number of different characteristics about particular words confirming that learning had occurred rather than as a result of purely random responses (i.e. by chance). Ten participants were reassessed 3-5 days following the final training session i.e. delayed recall assessments – the two lowest scoring participants declined. All ten demonstrated some ability to retain the newly learned information in long-term memory with the highest recall score being 82% (i.e. raw score of 263.5 from a possible maximum total of 320) and the lowest of 17.5% (i.e. raw score of 56 from a possible maximum total of 320). The percentage of information recalled from the delayed recall assessments was compared with immediate recall assessments and it was noted that the percentage of information retained from the training sessions varied from 83% to 49% of information. There were no instances of participants recalling information about the new words in delayed recall that had not already been recalled in immediate recall assessments.

The disparity in the ability of participants with aphasia to learn the new vocabulary mirrored the variability within the normal population's performance in the preliminary studies (see Chapter 3). Qualitative data revealed some similarities in error patterns which both populations shared; semantic errors in word-picture matching tasks, phonemic errors in retrieving the new word forms, circumlocution when describing characteristics of target words that were not recalled and some between-session interference of the new words or associated meanings. However qualitative data also identified notable differences in error patterns between the two populations. Firstly, it was noted that participants with aphasia took a longer time to retrieve target responses than the normal population (for example, see participant C1 – section 5.5.2.1 and C3 – section

5.8.2.1). Secondly, the participants with aphasia characteristically presented with errors such as perseveration of phonemes and syllables within sessions, lexicalisation of new words, semantic and phonemic errors on already familiar words, spelling errors despite accurately recalling the new words in spoken form, and errors reading aloud despite being able to accurately spell the new words (see section 5.3). These error patterns suggest that participant performance was affected by factors other than normal variation and likely to be as a result of damage from their stroke (see section 5.3.1). Participants with aphasia presented with diverse personal profiles, for example different ages, years in education, months post-stroke, cognitive and language functioning. It was speculated that these factors may have accounted for the variability in performance by participants with aphasia in the learning and retention of the new vocabulary and were therefore examined in order to provide some explanation for this variability.

6.3 FACTORS AFFECTING THE LEARNING OF NEW VOCABULARY

The ability of people with aphasia to learn new vocabulary has now been established. As discussed above participants with aphasia presented with variability in performance, similar to that of the normal population in the preliminary studies (see Chapter 3). However qualitative characteristics presented by the participants with aphasia alone suggested the influence of intrinsic factors that may have affected the learning and retention of the new vocabulary or the demonstration of this learning in the assessment tasks. A review of the literature in Chapter 2 identified a number of factors that impacted upon the recovery of aphasia which included pre-morbid presentations, biological limitations, initial functional severity and the level of aphasia rehabilitation initially received by participants following their stroke (see section 2.6). Individual profiles of participants with aphasia identified a wide range of pre-morbid presentations and functional severity. These were appraised in order to evaluate if those factors which affected the recovery of aphasia also impacted upon the ability to learn and/ or retain new vocabulary. This data would contribute to information about new learning in the language domain and also inform language rehabilitation theory by identifying factors that may impact upon the potential to learn new words. The various factors are now presented and discussed in relation to how they were measured; an evaluation of the method of measuring the factors, where appropriate; the impact of these factors on the learning of new vocabulary as tested by statistical correlations; and the implications for new learning in the language domain. It is noted that these observations do not reflect the effect of individual factors in isolation but rather a pooling and interaction of all relevant factors. Additionally, while the results from the statistical analyses in Chapter 5 represent the group of participants as a whole, individual participant variances from the group findings were noted and will be discussed for each factor. The factors are now presented and discussed under various headings. Those factors considered to be personal attributes incorporated participants' age, education, cognitive reserve, emotional status and stage of recovery (see section 6.3.1 and sub-headings). Biological limitations are also discussed (see section 6.3.2). Cognitive abilities and the capacity to learn incorporated a number of factors including, attention, memory, executive functions, non-linguistic learning and clock drawing skills (see section 6.3.3 and sub-headings). The language ability of participants (see section 6.3.4 and sub-headings) and learning strategies used by participants (see section 6.3.5) were considered important factors to evaluate and are also discussed below.

6.3.1 Personal attributes

The factors considered under the heading of personal attributes incorporated the age of participants, the number of years spent in formal education, emotional status of anxiety and depression and the number of months post-stroke.

6.3.1.1 *The impact of age on the learning of new vocabulary*

As the literature indicates, the evidence is equivocal regarding the impact of age on the recovery from aphasia. Some evidence suggests that age is not a prognostic factor in the recovery from stroke, whereas other evidence indicates that overall younger people demonstrate better recovery than older adults following cortical damage (see section 5.4.2.1). The age of participants in the main investigation varied between 33;11 to 64;04 years of age and it was predicted that younger participants would demonstrate better learning of the new vocabulary than older participants. The hypothesis, *'age correlates negatively with the recall of new vocabulary'* was supported both for immediate ($r = -.755$; $p<.01$) and delayed ($r = -.597$; $p<.05$) recall (see section 5.18.2.1). This factor was the second strongest correlation according to ranking in this category for immediate recall, indicating that younger participants with aphasia were able to learn and recall more vocabulary than older participants. This finding is consistent with Robertson and Murre's (1999) assertion that although cortical plasticity is evidenced for the adult population, the potential for recovery is greater for younger adults. This also appears to be true for the acquisition of new vocabulary with younger participants being able to learn and retain more information about the new words both in immediate and delayed recall than older participants. This group trend implies that older people do not learn as well as younger adults which could have implications for the rehabilitation of older people with aphasia, particularly in light of the overall findings that new learning could be part of the underlying process in the restitution of language. This trend could suggest that people with aphasia over the age of 65 are unlikely to learn new information (in the language domain) and therefore perhaps it would not be worth providing them with rehabilitation. However group findings identified a continuum of ages rather than two distinct groups of young versus older participants. Additionally, individual participant performance indicated that there was nothing to suggest that the older someone was the less they could learn. P3 for example, who was the oldest participant was ranked second in the main investigation, achieving the second highest learning score (although he only remembered 49% of this information), whereas C11 was one of the youngest (aged 45;03 at the time of the investigation) but was ranked 12th having learned the least amount of new information. While P3 was ranked last in the amount of information retained from the training sessions (retaining 49% of information originally learned) this was not true for all older participants. C3 who was the third oldest participant, ranked third in the amount of information retained i.e. 74%. Therefore a blanket statement cannot be made regarding older people's ability to retain newly learned vocabulary.

6.3.1.2 The impact of education on the learning of new vocabulary

The level of education that a person has experienced throughout their lifespan is another factor in the literature relating to the recovery of language function for which equivocal findings have been reported (see section 2.6.1.2). Research suggests that the more education that a person experiences, the greater the complexity and number of neuronal patterns that they develop in the language areas of the brain. However it has not yet been ascertained if this complexity is as a direct result of the education experience itself (Jacobs et al., 1993b). Additional research indicates that the education experience develops skills required for learning, such as planning, memorising and problem solving (Robertson 1999). The number of years of formal education experienced by participants with aphasia in the main investigation varied from nine to 21.5 years. It was therefore predicted that participants with a greater number of years in education would demonstrate better learning of the new vocabulary than participants with less education experience. The hypothesis *'the number of years in education will correlate positively with the recall of new vocabulary'* was supported for both immediate ($r = +.869$; $p<.01$) and delayed ($r = +.847$; $p<.01$) recall. This factor was the strongest correlation according to ranking in this category for immediate recall and the second strongest for delayed recall. These findings are consistent with Robertson's (1999) assertion that the more years in education that an individual experiences the more learning skills they acquire. The findings are also possibly consistent with the assertion that the more education individuals experience leads to more complex and greater neuronal patterns pre-morbidly, which may be less easily destroyed when damaged (see section 2.5). However brain-scanning techniques would be required to provide evidence for this hypothesis.

6.3.1.3 The impact of cognitive reserve on the learning of new vocabulary

Interestingly, qualitative examination of the employment experience of participants appeared to reflect participants' learning performance. With the exception of C3, participants with employment requiring more specialist skills such as pharmacy, engineering and managerial posts appeared to demonstrate more success at learning the new words than participants who experienced less skilled employment, such as factory work and homemaking. However these highly skilled participants have also experienced more education therefore more complex occupations may reflect long-term intellectual experiences resulting from education rather than employment status itself being a prognostic factor in learning new vocabulary.

Another possible explanation could be related to the hypothetical cognitive reserve discussed in Chapter 2 (see section 2.6.1.3). Although not statistically analysed in the main investigation, qualitative data indicates some interesting findings. Two of the factors thought to influence and accumulate cognitive reserve are education and occupational levels. The type of occupation pursued by an individual is thought to contribute significantly to their non-verbal reasoning (Staff et al., 2004) and complex occupations are thought to require continuing education and sustained intellectual engagement, requiring mental effort and learning the ability to conceptualise problems (Stern, 2003). Additionally, both occupation and education are thought to act as reserves for verbal memory. Those participants who had experienced more education (13 years or greater in this investigation) also presented with less severe aphasia than the other participants in this study. Additionally, these participants also learned a significant amount of information about the new words. The converse also appeared to be true. Those participants who experienced less than 13 years of education in this investigation (four participants) also appeared to be more severely aphasic and learned less information about the new vocabulary than the other participants. Three of these participants (C9, C10 and C11 - the lowest scoring participants) were also those who were unable to fractionate the learning tasks for individual learning time and required close guidance from the researcher. These were also the participants who were employed in jobs that were less complex, for example more manual, automatic and repetitive occupations such as factory and cleaning jobs. Those participants with more complex occupations such as engineering, pharmacy and managerial work appeared to use more fractionating of tasks and organised thought, perhaps with more experience of planning, problem solving and sequencing. The group trend in this investigation is consistent with this hypothesis as participants with more active factors thought to accumulate cognitive reserve, i.e. high education and occupation levels, also presented with less severe aphasia and learned more vocabulary than less educated and less skilled participants. There were two exceptions to this – C3 who was a homemaker and C11 who had 15 years in education. C11 (who was the lowest scoring participant) was employed in a manual occupation (bookbinding). C3 was ranked fourth in the ability to learn the new vocabulary retaining 80% of this new learning. She worked as a homemaker due to a long history of ill-health therefore it is not possible to establish what occupational level she might have achieved if she pursued a career outside the home.

As the main investigation findings suggest that new learning could be a process involved in aphasia rehabilitation should those less educated, less skilled individuals be excluded from the therapeutic process? It would of course be unethical, even perhaps illegal, to offer rehabilitation only to those with higher education and more skills. Additionally, there is a paucity of research evaluating the contribution of educational experience to language restitution and recent evidence has not found it to be a prognostic factor in the recovery from aphasia (see section 2.6.1.2). However as new learning could be an underlying process involved in language rehabilitation, the impact of education requires consideration in facilitating the restitution of language function. Would it be possible to enhance a person's recovery through teaching them new ways of learning? Perhaps it would be important to initially discover each person's own particular methods of learning and adapt therapy methods to facilitate their therapy accordingly to promote better restitution of language function.

6.3.1.4 The impact of emotional status on the learning of new vocabulary

The evidence from the literature is unambiguous regarding the impact of emotional status on recovery from aphasia (see section 2.6.3.2). Apathy, anxiety and depression impact upon quality of life and post-stroke depression is considered to be one of the strongest factors impairing recovery. Such emotional difficulties also affect a person's cognitive abilities (see section 2.6.3.3) as well as their motivation and language performance (see section 2.6.3.2). The emotional status of participants with aphasia was measured using the HADs self-rating scale (Zigmond and Snaith, 1983 – Appendix 4.2). The HADs revealed great variability among participants' emotional status with results ranging from anxiety and depression levels of within normal limits to severely impaired. The hypothesis *'a self-rating of anxiety will correlate negatively with the recall of new vocabulary'* was supported for immediate ($r = -.672$; $p<.05$) but not delayed ($r = -.274$; $p=.237$) recall. The hypothesis *'a self-rating of depression will correlate negatively with the recall of new vocabulary'* was also supported for immediate ($r = -.562$; $p<.05$) but not for delayed ($r = -.400$; $p=.143$) recall. This suggests that the emotional status of participants impacted upon their acquisition of the new vocabulary, i.e. creating new memory traces and related neuronal connections, but once learned was not a significant factor in the retrieval of these newly acquired words. These findings are consistent with evidence from the literature that reports that emotional status impacts negatively upon the linguistic performance of people with aphasia. While the biological nature of depression is acknowledged, the daily social factors that affect participants cannot be ignored. This aspect of social emotional influences were observed with a number of main investigation participants and was reflected in their HADs scores. During the training sessions C3 (abnormal anxiety levels) discussed her fears at being at risk of future strokes. C6 (abnormal anxiety and depression levels) revealed his frustration and disappointment at remaining in a difficult situation and C10 (abnormal anxiety and depression levels) discussed her bereavement and fears for the future. The self-rating HADs scores reflected the impact of the social factors relating to C3, C6 and C10 and also likely impacted upon their ability to learn new vocabulary.

These findings suggest explicit implications for the rehabilitation of language, particularly in the timing of therapy and the type of speech and language therapy provided. As the literature indicates, depression can occur in both the acute and chronic stages of recovery from stroke (see section 2.6.3.2). This influences a person's motivation, language and cognitive processes, in particular attention and memory (see section 2.6.3.3). Therefore it may be more appropriate not to offer direct therapy until such time as a person's emotional status recovers but instead provide indirect therapy, for example working with family and carers in terms of support and education of compensatory techniques to help facilitate communication. Direct therapy could begin when emotional stability returned to within normal limits and the person with aphasia was better able to actively participate in the therapeutic process. As depression can occur at any stage of recovery from stroke it would be important to note any deterioration in mood with individuals and postponing direct therapy input until an appropriate time. Additionally, liasing with the multidisciplinary team could accelerate the assessment and treatment of emotional impairments and inform the decision as to when direct language therapy could commence.

6.3.1.5 The impact of stage of recovery from stroke on the learning of new vocabulary

The literature suggests some evidence for cortical plasticity occurring in the chronic stage of recovery. This stage of recovery is normally considered to involve the learning of compensatory techniques rather than restoration of language (see section 2.2.1). The number of months post-stroke was used to denote the recovery stage for each participant. The stages of recovery for participants in the main investigation varied from five to 146 months post-stroke. As indicated, this investigation predicted that as the brain may be more biologically/ medically stable in the chronic stages of recovery it might have more potential for learning-related cortical plasticity (see section 5.4.2.1). The hypothesis *'the number of months post-stroke will correlate positively with the recall of new vocabulary'* was supported for both immediate ($r = +.629$; $p<.05$) and delayed ($r = +.895$; $p<.01$) recall. These findings are consistent with the theory that participants in the chronic stages of recovery have the ability to learn more vocabulary than those in the more acute stages. Additionally, as certain approaches to learning indicate that new learning invokes cortical plasticity (for example, Hebbian learning), the support of this hypothesis is consistent with the suggestion that such plasticity is likely to be occurring in the chronic stages of recovery. In terms of aphasia rehabilitation this infers that language therapy would be appropriate for people with chronic aphasia, indicating that referrals and re-referrals from such individuals should not be dismissed as inappropriate. It is also likely that depression due to an organic aetiology resulting directly from brain injury would have resolved at this stage. However as previously discussed, depression could still be a problem as a result of experiencing limited functional ability, part of the grieving process and various social factors experienced by many people following a stroke (see section 2.3.1). The ability of people with chronic aphasia to learn new information should not however infer exclusion of those adults in the acute stages of recovery. Individual participant profiles indicated that people could also learn new vocabulary at this stage. P3 for example, was ranked second in the amount of new learning demonstrated yet he had experienced his stroke only seven months prior to participation in the main investigation. These findings are consistent with the literature which report positive outcomes in the acute stages following a stroke although the effect was not as great as those with chronic aphasia (see section 2.6.4.1).

6.3.1.6 Summary

The hypotheses relating to the impact of age and education on the acquisition of new vocabulary have been supported, indicating that participants who were younger and more educated learned more new vocabulary than older and less educated participants. The findings of this investigation are also consistent with the concept of cognitive reserve as participants with more education and more complex occupational levels learned more vocabulary. Therefore an ideal patient would appear to be one who is young and highly educated, perhaps being in highly skilled employment. However as individual participant learning performance indicated this was not true for every individual. As suggested older patients should not be discarded because of their age alone, a view which is consistent with extensive literature which acknowledges that experience-dependent cortical changes occur throughout our lifespan (Mateer and Kerns, 2000). However plasticity in the normal population is not limited by age as people continue to learn throughout their lifetime despite age-related degenerative processes. Educational experience alone should also not determine who might be appropriate for therapeutic intervention as it may be possible to teach less educated patients new methods of learning to facilitate successful language rehabilitation. It could be speculated that these hypotheses would also be supported for learning investigations involving the general population rather than being solely indicative for people with aphasia. Current theories on the negative effects of emotional status on linguistic performance by people with aphasia have also been supported and can now be extended to impacting on the ability to learn new vocabulary. This finding has implications for the timing and type of intervention provided to patients and their families. The findings of this investigation could possibly be extended to the ability to learn new vocabulary by non-aphasic populations who also experience anxiety and depression, as such emotional disturbances have been found to affect cognitive processes including attention and memory.

The findings also demonstrated the ability of people with chronic aphasia to learn new vocabulary suggesting related cortical plasticity up to and including 146 months post-stroke (as suggested by C10 who was 146 months post-stroke). This finding is consistent with literature evidence where recovery from aphasia was demonstrated for individuals with an average of 8.5 years post-stroke when given intensive therapeutic input (Pulvermüller et al., 2001). The success of the type of therapeutic input with people with chronic aphasia has implications for the health care system which is not currently capable of providing such intensive rehabilitation (Meinzer et al., 2002). Alternatives to direct intensive therapy could involve the training of carers or family members, or perhaps use computer-based training programmes for people to practise daily therapy tasks in their own homes (Meinzer et al., 2002). While participants with chronic aphasia demonstrated a greater ability to learn and retain new vocabulary than those in the more acute stages of recovery, this was not to the exclusion of those participants with acute aphasia who also demonstrated new vocabulary learning. There did not appear to be any inherent interactions between the various factors, for example older participants did not appear to be more anxious or depressed than younger ones and emotional impairment was not noted to be related to levels of educational experience.

6.3.2 Biological limitations

The literature review discussed the methodological difficulty in evaluating the impact of the biological factors independently. The relationship between the magnitude and location of brain lesions is complex and appears to be interlinked with the initial severity of functional deficit experienced (which in this case is aphasia) (see section 2.6.2). The provision of brain-imaging data of participants prior to and following the training of new vocabulary could inform as to the impact of size and/ or site of cortical damage in new vocabulary learning and related cortical plasticity. The prognostic influence of stroke aetiology has not been thoroughly researched, specifically the issue of infarct versus haemorrhage, and early results were conflicting (Basso, 1992). Four of the participants with aphasia in the main investigation had a history of multiple strokes – C3, C6, C10 and C11. As observed (see section 5.3), despite experiencing multiple strokes, C3 and C6 were ranked fourth and seventh respectively in their ability to learn the new vocabulary and both retained 80% of this information in delayed recall tasks. However C10 and C11 learned the least amount of new vocabulary and also experienced haemorrhagic in addition to multiple strokes – a combination of which may have affected their performance. Due to sample size and the absence of brain-imaging data it would not be prudent to speculate about either the effects of the type of stroke (i.e. infarct versus haemorrhage) or the number of strokes on the successful ability to learn new vocabulary. It would be informative in future research to ascertain the impact of aetiology, site and extent of brain damage on the ability to learn new vocabulary and related cortical plasticity.

6.3.3 Cognitive abilities and the capacity to learn

The difficulty in measuring cognitive functioning has been acknowledged, particularly following a stroke, with many assessments considered as unsuitable for people with aphasia (particularly those requiring spoken and/ or written responses) (Starr et al., 2000). However the Cognitive Linguistic Quick Test

(CLQT) was developed as a screening assessment for adults with acquired neurological impairment (Helm-Estabrooks, 2001) and was therefore considered appropriate to screen the cognitive strengths and weaknesses of main investigation participants. The lack of depth in such a screening tool is acknowledged, however the deductions made from it in relation to new vocabulary learning was secondary to the main research question which aimed to ascertain whether people with aphasia could demonstrate the ability to learn new vocabulary. The factors considered under the heading of cognitive abilities were attention, memory, executive function and clock drawing skills. The evidence for the impact of attention, memory and executive functions on language recovery and the acquisition of new learning are discussed in the literature review (see section 2.6.3.3). The clock drawing task is thought to involve attention, memory, executive function, visuospatial and language skills and has been reported to be in itself useful as a mini-screening tool for cognitive abilities (Helm-Estabrooks, 2001). While the CLQT revealed visuospatial impairments in a number of participants, all had adequate visual skills to copy the stimuli (pictures and words). Therefore any visuospatial impairment did not affect participant ability to interact with the stimuli, questioning the robustness of the CLQT for the functional assessment of these skills. The cognitive capacity of each participant to learn was also evaluated by assessing the ability to learn and recall a non-linguistic route task devised by the researcher based on a previous study (Evans et al., 2000). The findings related to the cognitive abilities and the capacity to learn will now be discussed.

6.3.3.1 The impact of attention on the learning of new vocabulary

The importance of attention in the processing of information has been discussed in the literature review (see section 2.6.3.3). The learning of new vocabulary required active participation in the training procedures and independent learning time in order to incorporate the new vocabulary into participants' current knowledge. Active participation included tasks such as drawing and copying, repeating, reading and listening as well as task completion. The CLQT revealed that attention abilities of participants varied from within normal limits to moderate impairment. As informed by the literature it was predicted that participants with moderately impaired attention would learn less vocabulary than those participants whose attention was within normal limits. The hypothesis *'attention is correlated positively with the recall of new vocabulary'* was supported for both immediate ($r = +.821$; $p<.01$) and delayed ($r = +.615$; $p<.05$) recall and for immediate recall appeared to be the strongest correlation by rank order in this category. While the group trend supported the hypothesis, this was not true for all participants, for example C4 presented with moderate attention difficulties yet ranked fifth in learning new vocabulary recalling 67% (raw score 215 from a maximum total of 320) and remembered 67% of this information in delayed recall tasks. Conversely, C8 presented with attention abilities of within normal limits yet only recalled 48% of information about the new vocabulary (raw score 154.5 from a maximum total of 320) and remembered 66% in delayed recall tasks. The overall group trend is consistent with the literature which reports that attention directly interacts with language processes and is required for the acquisition of new information or skills (see section 2.6.3.3). Those participants therefore who had attention impairments were unable to invoke top-down gating of the new vocabulary despite being actively involved in the learning process, resulting in reduced related neural plasticity and connectivity. These findings have implications for the timing and type of language rehabilitation offered to people with attention difficulties, suggesting that such individuals would not benefit from therapeutic input until they receive rehabilitation for attention impairments. Additionally, attention is affected by the presence of depression so it may be useful to liase with the multidisciplinary team to ensure that individuals are not experiencing depression.

6.3.3.2 The impact of memory on the learning of new vocabulary

As discussed in the literature review (see section 2.6.3.3) memory processing impairments often co-exist with aphasia following a stroke. Performance on memory sub-tests of the CLQT revealed varied memory processing abilities, ranging from presentations within normal limits to severely impaired. As memory processes are required to acquire and consolidate new learning, it was predicted that participants with memory abilities within normal limits would learn more vocabulary than those with memory impairments. The hypothesis '*memory is correlated positively with the recall of new vocabulary'* was supported both for immediate ($r = +.935$; $p<.01$) and delayed ($r = +.905$; $p<.01$) recall and was the strongest correlation for both assessments. This finding is consistent with the literature regarding the involvement of memory processing in acquisition, consolidation, storage and retrieval of information (see section 2.6.3.3). Therefore as would be expected, memory impairment had a direct impact on the ability to acquire, store and recall the new vocabulary.

However there were concerns that the memory subtest scores of the CLQT did not give an accurate picture of the memory abilities for all participants. Some participants with severe aphasia were unable to respond to tasks in spoken form but responded accurately through gesture and/ or writing (in particular C2). CLQT only accepts spoken responses as correct, thereby underestimating the memory score for some participants. Additionally, in many cases participants presenting with impaired memory processing abilities according to the CLQT demonstrated the ability to learn and recall the non-linguistic route task. Some participants also presented with moderate memory impairments yet demonstrated the ability to learn and recall the new vocabulary for example, C3 was ranked 3rd recalling 83% of information (raw score 284 from maximum total of 320) and remembered 80% of this information in delayed recall tasks. Additionally C4, who presented with moderate attention and moderate memory processing according to the CLQT, ranked fourth recalling 67% of information (raw score of 215 from maximum total of 320) and remembered 67% of this information in delayed recall tasks. Individual participant performance suggests the CLQT is not a robust assessment for recording overall cognitive processing ability, particularly with people who are unable to respond in spoken format. So although the statistical correlations supported the hypotheses, it was considered that the memory processing abilities of some participants were underestimated. The implications of memory processing impairment for language rehabilitation relate to the type of language therapy treatment provided and suggest that where possible memory processing impairment should be treated before language intervention. Therefore it would be appropriate to evaluate memory processing ability prior to language rehabilitation. This discussion indicates that a more robust measurement of memory processing abilities must be evaluated for this end – one that depends less on spoken responses.

6.3.3.3 The impact of executive functions on the learning of new vocabulary

Executive function impairments have also been reported to co-occur with aphasia following a stroke and affecting the ability to plan spoken communication and monitor and correct errors such as perseveration (see section 2.6.3.3). Therefore it was predicted that participants with executive function impairment would not be able to demonstrate the learning of new vocabulary as much as those without such impairment. The CLQT revealed various levels of executive function impairment for participants in the main investigation ranging from within normal limits to severe impairment. The hypothesis *'executive functions are correlated positively with the recall of new vocabulary'* was supported for both immediate ($r = +.670$; $p<.05$) and delayed ($r = +.603$; $p<.05$) recall. This finding is consistent with the literature that reports the importance of executive functioning in the complexity of communication. Difficulties planning, fractionating tasks and problem solving were apparent with some participants in the training procedure, for example C9, C10 and C11 (executive scores of moderate, mild and severe deficits respectively) were unable to organise their independent learning time and required close guidance from the researcher. These participants also presented with attention and memory impairments. However, P3 presented with mild executive functioning deficit but was ranked second in his ability to learn the new vocabulary. The group trend therefore suggests that people presenting with executive function impairment may not be candidates for language rehabilitation depending upon the level of deficits. Again it may be more appropriate for cognitive rehabilitation to precede language intervention. In cases where people with executive function deficits do not improve, it may indicate that they are also not likely to benefit from language rehabilitation.

6.3.3.4 The impact of non-linguistic learning on the learning of new vocabulary

As previously described (see section 4.2.2.2) the general capacity to learn was assessed using a non-linguistic task where participants were required to learn and recall a specific paper-based route. Participant ability to learn the route varied from zero to 100%. As the non-linguistic route represented a demonstration of participants' general capacity to learn, it was predicted that participants who were able to demonstrate the ability to learn would be able to demonstrate the ability to learn new vocabulary in the language domain. The hypothesis '*non-linguistic learning is correlated positively with the recall of new vocabulary'* was not supported for either the immediate ($r = +.132$; $p=.367$) or delayed ($r = +.085$; $p=.414$) recall. This suggests that the ability to learn the non-linguistic task is not related to the ability to learn new vocabulary. Different parts of the brain may be involved in these types of learning. However, the non-linguistic route task was evaluated as a useful tool in identifying the capacity to learn – C10 and C11 (participants with the lowest learning performance) achieved 33% accuracy and zero accuracy respectively. However C8 and C9 achieved 100% accuracy in learning the non-linguistic route yet were ranked ninth and tenth in the ability to learn new vocabulary. Therefore there does not appear to be any merit in using this test as a prognostic tool for language rehabilitation. It might be useful however, to evaluate the recovery of a person from aphasia and their ability to learn more complex non-linguistic tasks that may be more sensitive for executive function and memory recruitment.

6.3.3.5 The impact of clock drawing task on the learning of new vocabulary

Helm-Estabrooks (2001) advises that the clock drawing task recruits all five cognitive processes, i.e. attention, memory, executive function, visuospatial skills and language, and can therefore be used independently as a mini-screening assessment of cognitive functioning. The data from this task was analysed to ascertain if the clock drawing task might be useful as a prognostic factor in new vocabulary learning. Participant ability to complete the clock drawing task varied from within normal limits to severely impaired. As cognitive processes have been shown to be important in the acquisition and recall of new information and in language processing itself (see section 2.6.3.3) it was predicted that participants who had good clock drawing skills would learn more vocabulary than those with no impairment for this task. The hypothesis '*clock drawing skills are correlated positively with the recall of new vocabulary*' was supported both for immediate ($r = +.774$; $p<.01$) and delayed ($r = +.706$; $p<.05$) recall. This suggests that the clock drawing task may be a prognostic tool for predicting the ability to learn new vocabulary. While this task is reported to involve the integration of many cognitive processes, it seems divorced from language processing. However, it may be beneficial to evaluate its usefulness as a screen for cognitive processes. Although the group trend suggests a correlation between clock drawing skills and learning new vocabulary, individual data highlights exceptions such as C5 and C6 who both presented with severely impaired clock drawing abilities yet learned 62% and 59% of information respectively (raw scores 199 and 189.5 respectively from maximum total of

320). Additionally, the CLQT indicated that C6's attention, executive functions and visuospatial skills were within normal limits and while he presented with moderate memory difficulties, instructions for the task were presented in written form, which could be read time and again. It was therefore not possible to identify what cognitive difficulties affected C6's ability to complete this task. Therefore it is not possible to predict the usefulness of this task. Its robustness in assessing the various components of cognitive ability or claims for the predictive ability of the clock drawing task are questionable.

6.3.3.6 Summary

The hypotheses relating to the impact of attention, memory and executive functions on the acquisition of new vocabulary have been supported for both the learning and retaining of new vocabulary. This group trend indicated that the greater the impairment in these cognitive domains, the more impact there was on the ability to demonstrate the learning of new vocabulary. It is speculated that, as indicated by the literature (see section 2.6.3.3), these hypotheses would also be supported for learning investigations involving populations other than stroke who experience these cognitive impairments. However, it was felt that more robust cognitive screening assessments (based on a robust theoretical model) should be used to facilitate the measurement of cognitive domains for people whose language difficulties may underestimate their cognitive abilities. The group trends suggest that the most appropriate person for language rehabilitation would be someone who had intact attention, memory and executive function because of their learning potential, however mild impairments would appear to be adequate for rehabilitation as demonstrated by P3 who was mildly impaired in all cognitive domains but ranked second in his ability to learn the new vocabulary. Fillingham, Sage and Lambon Ralph (2005) report that immediate and long-term improvements of naming ability related to participants' executive functions and recognition memory, therefore these abilities impact not only upon the learning of new vocabulary but also the restitution of a damaged language system. Intervention for cognitive impairments has been reported to be successful for both improving cognitive functioning as well as decreasing severity of aphasia (Helm-Estabrooks, 1998). Therefore the treatment of higher order cognitive impairments should precede language rehabilitation (Van Mourik, Verschaeve, Boon, Paquier and Van Harskamp, 1992) or at least the provision of support which may facilitate the expression of other relatively intact abilities (Manley, Hawkins, Evans, Woldt and Roberston, 2001). Higher order processes are not yet completely understood. Currently there are a number of researchers investigating the fractionation of higher order processes with a view to developing a comprehensive theory which is anticipated to result in more successful instrumentation, for example, intelligence (Anderson, 2001), theory of mind (Stone, 1999), social cognition (Lough, Kipps, Treise, Watson, Blair and Hodges, in press) and higher cognitive process impairment observed in dementia (Salmon and Hodges, 2005).

6.3.4 Language ability

The language abilities of participants were observed using a number of language assessments. The pre-training language screening assessment was compiled by the researcher and included extracts from published assessments and picture stimuli from the literature to evaluate both spoken and written single word processing abilities (see section 4.2.3). The language sub-test of the CLQT assessed the spoken language abilities of participants with tasks such as giving personal facts (i.e. name, address, date of birth etc.), confrontational naming, story retelling and generative naming (see section 4.2.2.1). Additionally, participants were asked to narrate the Cinderella story both in spoken and written form. The Cinderella story was not analysed but rather provided qualitative data on participant language in connected speech (see section 4.4.4.2 and Appendices 5.3a to 5.3h).

6.3.4.1 Pre-training language screening assessments

The initial severity of aphasia is considered to be a prognostic factor in its recovery (see section 2.6.3.1) however this information was not available for this investigation. Instead the severity of aphasia of each participant was measured immediately prior to participation in the main investigation and the impact of aphasia severity was assessed using this data. The language ability of participants was assessed using the sub-test of the CLQT (Helm-Estabrooks, 2001) and data provided by the pre-training language screening assessments (see section 4.2.3). There was a range of severity of aphasia among participants. The CLQT language sub-test data indicated language processing abilities ranging from within normal limits to severely aphasic. The range of aphasia scores from the language screening assessments varied between 94% (raw score of 124.5 out of a possible maximum of 133) to 51% (raw score of 68) – the lower scores indicating more language severity. It was speculated that participants with more severely impaired language abilities would learn fewer new words than their less severely aphasic peers. The hypothesis *'severity of aphasia is positively correlated with the recall of new vocabulary'* was supported for immediate recall by both the CLQT ($r=+.605$; $p<.05$) and pre-training language assessments ($r=+.769$; $p<.01$) as well as delayed recall ($r=+.741$; $p<.05$ and $r=+.680$; $p<.05$ respectively). This indicates that participants with severe aphasia learned less new vocabulary than those who were less severely impaired.

However the severity ratings of the CLQT language subtest did not appear to equate with those of the language screening assessments, for example the CLQT found C5 and C4 to be severely and moderately impaired respectively yet they achieved 95.9% and 90.2% accuracy respectively on the language screening tasks. Other participants who were rated as severely impaired by the CLQT achieved between 51% and 95.9% accuracy for pre-training language screening assessments. These findings indicated that the CLQT is not a sensitive measure for severity of language processing and only appeared to measure the spoken ability of participants rather than their overall language ability. The pre-training screening assessments appeared to be robust in recording language abilities and deficits for single word processing. However, two participants scored within normal limits and mildly aphasic on the CLQT (C1 and P3 respectively) and also scored highly in the language screening assessment (93.2% and 93.6% respectively). Neither assessment revealed the extent of these participants' language impairment, which was only highlighted in tasks involving connected speech and were revealed in the narration of the Cinderella story (see Appendices 5.3a and 5.3b respectively). This narration revealed perseveration (for example C4 and C8), word-finding difficulties (for example, C1 and P3) and impaired grammatical constructions (for example, C6 and C7) (see Appendices 5.3a-5.3h).

6.3.4.2 Main investigation language assessments

As the various assessment tasks in the main investigation facilitated the demonstration of new vocabulary learning in ways other than, and in addition to spoken and/or written responses, the findings were considered to be a true reflection of the ability to learn the new words. To ensure that non-verbal aphasic participants were not placed at a disadvantage when evaluating their ability to learn the new vocabulary (as spoken or written ability would produce higher scores) the assessment tasks that required spoken or written responses were subtracted from the total raw scores. The remaining data reflecting non-verbal responses indicated that individual rankings of participants changed slightly but the original top three participants (C1, P3 and C2) remained in this position, as did the lowest scoring participants (C9, C10 and C11) (see Table 5.2 and section 5.3). Therefore the original immediate and delayed recall scores (i.e. including spoken and written responses) were felt to be reflective of participants' overall ability to learn the new vocabulary. The use of the cognitive neuropsychological approach in depicting the individual single word processing abilities of each participant and as a tool for predicting their performance on new learning tasks is discussed below (see section 6.5).

6.3.5 Learning strategies

The preliminary studies indicated that no one learning strategy was suitable for all participants therefore, as previously discussed, participants in the main investigation were given information explaining various learning techniques and were advised to use the one(s) they found most suitable (see section 3.3.3). Additionally, participants were given a maximum of 30 minutes in each training session to promote independent rehearsal and consolidation of the newly learned words in any way they wished. In order to reduce errorful learning, reduce assessment task artefact and to help structure the learning period, participants were given a number of tasks they could complete for this learning (see Appendix 4.7). Qualitative data indicated that on the whole participants listened to the audio recording of the details about the new words as well as practised the assessment tasks. Some participants wrote down all details as they rehearsed them and others practised the details aloud. However, the three participants with the lowest learning performance (C9, C10 and C11) were unable to structure their independent learning time and required direct guidance from the researcher who gave them the opportunity to complete the same tasks as other participants. This suggests poor planning ability and may reflect their cognitive impairments, in particular executive function. It could also reflect depression and anxiety levels of participants possibly exacerbating existing cognitive difficulties. It was noted that on the whole participants who employed more independent learning time were also more educated, perhaps reflecting the knowledge of how to learn effectively. These same people were also employed in occupations of higher complexity than other participants, perhaps suggesting the usefulness of cognitive reserve in the learning process.

It was not possible to quantify the benefit of the independent learning experience or the strategies used by participants to rehearse and consolidate their learning. However the amount of time used by participants was recorded and measured against their learning score to ascertain if the length of rehearsal and consolidation time impacted upon the amount of vocabulary learned. It was predicted that those participants who took more time to rehearse and consolidate the new words would learn and remember more new vocabulary than those who used less independent learning time. The hypothesis, '*independent learning time is correlated positively with the recall of new vocabulary'* was supported both for immediate ($r=+.890$; $p<.01$) and delayed ($r=+.759$; $p<.05$) recall assessments. This indicates that the longer participants spent consolidating the new vocabulary the more successful they were in learning the new words and then retrieving them from long-term memory. This is consistent with the literature that reports a need for repetition and consolidation of learning, in particular Hebbian learning paradigms where the more frequently cells fire together the stronger they wire together to form representations of the new words.

Implications for language rehabilitation include the provision for adequate time for repetition and consolidation of therapeutic stimuli as well as ensuring that the correct representation and connection is being formed during this time, perhaps in the form of errorless learning. The errorless learning approach was employed in the training procedure for this investigation, where every effort was made to promote the learning of accurate representations of the new words and elimination of any errors. Errorless learning may be an appropriate approach to employ in the rehabilitation of language. As discussed in the literature review (see section 2.9.2), this method has proved useful for many people particularly those with memory processing impairments. Fillingham et al. (2005) highlight the paucity of research which employs errorless learning for the amelioration of aphasia and stress the difficulty in designing therapy that would result in the person with aphasia only ever producing correct responses. Recent findings suggest that while participants strongly preferred errorless learning techniques, being less frustrating and more rewarding than errorful techniques, errorless learning produced equivalent results to errorful learning in the rehabilitation of anomia (Fillingham et al., 2003; Fillingham et al., 2005). However as there appears to be a paucity of research in this area and all participants in the above investigations did not improve to the same extent, further exploration is warranted. This investigation has highlighted the different learning styles of participants in the preliminary, pilot and main investigation which may account for some of the variation in participant outcome. Perhaps further language therapy investigations should take this factor into account where people may gain further functional improvements using methods more suited to their own individual learning styles.

6.3.6 Summary

The factors affecting the learning of new vocabulary have been discussed as isolated entities. While the impact of each factor on both the recovery from aphasia and the ability to learn new language representations is considered important, in reality the various factors act in an integrated fashion. There is opportunity for future research to examine how each factor interacts and impacts one on another. A larger study would enable a more powerful investigation of the inter-relatedness of each of the factors and perhaps establish the relative strength of the impact of each individual factor on the recovery of language and new learning, for example whether the impact of depression is greater than the impact of severity of aphasia.

6.4 EVALUATION OF THE METHODOLOGY

6.4.1 Participants

Participants involved in the development of the stimuli and procedure in the preliminary studies were recruited from the Speech and Language Sciences Department in Queen Margaret University College, Edinburgh and employment status ranged from student and departmental secretary to lecturing and research staff (see Chapter 3). While these participants may be considered as unrepresentative of the general population as their professional focus is communication, the variability in their performance suggests that their linguistic experience did not appear to positively impact upon their performance in learning the new vocabulary (see sections 3.2, 3.3 and 3.5). The pilot studies included a speech and language therapist as the 'normal' participant. This enabled methodological issues which arose during the pilot study to be discussed with her and possible alternatives to the procedure considered in relation to her experience of the training and assessment procedures. The other two pilot study participants were recruited from local speech and language therapists. As discussed, the data for one of the pilot study participants (P3) was used in the main investigation. The other 11 main investigation participants were recruited from local speech and language therapists, groups for young people who had experienced stroke and a local college. Participants presented with different stroke histories – single strokes, multiple strokes, infarcts and haemorrhages. They also presented with a wide range of severity of cognitive, emotional and language functions as well as differing abilities to learn the new vocabulary. While it is acknowledged that the main investigation sample is not large enough to generalise the findings to the general population with aphasia, it was sufficient in number to demonstrate that adults with post-stroke aphasia can learn new vocabulary despite residual language impairments. Further investigations should endeavour to involve larger numbers of participants with a range of impairments to enable the use of more powerful quantitative and more informative qualitative statistics.

6.4.2 Methodology

As previous research had not investigated the ability of people with aphasia to learn new vocabulary, this investigation involved preliminary (see Chapter 3) and pilot (see Chapter 4) studies to develop and evaluate the original procedure and stimuli. The procedure and stimuli were evaluated using 75 adults with normal cognitive and language functioning representing the normal population and also with post-stroke individuals (one with and one without aphasia).

6.4.2.1 Nature and development of the stimuli

It was fundamental to the investigation that the stimuli were novel as this had been a methodological issue with previous new learning studies (see section 2.8.6). A number of ideas were considered including the identification of a foreign language that participants would not be familiar with, paired for example with ancient artefacts or abstract symbols. However it was considered that in today's technological climate many people have access to personal computers and the Internet. Additionally, there are also educational courses and television programmes that facilitate easy access to information about a variety of topics. Therefore it would not have been feasible to completely exclude the possibility of participants having encountered information about any of the matched pair stimuli. It was therefore necessary to create an original set of words incorporating novel word forms and novel meanings to ensure the stimuli were unknown to all participants. Common nouns were chosen over verbs and proper nouns as discussed in Chapter 2 (see section 2.9.1) and as the claims regarding reduced motivation of healthy adults to learn non-words were dismissed (de Groot and Keijzer, 2000) two and three syllable non-words were created. It was considered difficult to create symbols that would have no intrinsic meaning for all participants or be similar to the numerous symbols already in existence. Therefore black and white drawings of unusual 'creatures' were created and arbitrarily matched to the new word forms and were then randomly assigned to the four training sessions of the main investigation. To further strengthen the semantic characteristics of the new words, the creatures were given unusual skills which incorporated already familiar words, and by placing the new words into semantic categories (i.e. habitat and food) participants were enabled to form links with already held semantic knowledge. The preliminary and pilot studies evaluated the novel stimuli and confirmed their uniqueness and suitability for training participants with aphasia in the main investigation. The number of times each new word was recalled is detailed in Appendix 5.6. Words with three syllables did not appear to be harder to recall than those with two syllables. The reliability of performance across the four training sessions was assessed and found to correlate indicating that the participants found the stimuli in each training session equally challenging to learn.

The new vocabulary were trained both in single word format and associated with already known information (i.e. skills, habitat and food). It is acknowledged that the investigation assessed single word responses rather than incorporating the social usage of language in sentence / conversational format. However vocabulary by its very nature is generally learned in single word form and then the newly learned word is incorporated into a person's connected speech in conversation. The aim of the investigation was to assess if people with aphasia could learn the novel vocabulary and to facilitate this, the cognitive load required from participants was reduced to single word level.

6.4.2.2 Development of the methodology

The methodology was developed in consideration of current research evidence. In an effort to facilitate optimum learning by participants with aphasia proven learning strategies were incorporated into the methodology where possible, for example pre-exposure techniques, self-judgement tasks and an errorless learning approach was followed (see section 2.9.2). The evolution of the training process is presented in the preliminary (see Chapter 3) and pilot studies (see Chapter 4), which confirmed that the methodology was suitable for training and assessing the learning of new vocabulary. Pre-training assessments provided baseline measures for cognitive, emotional and language abilities (see section 4.2 and sub-tests). The training procedure incorporated auditory, written and picture stimuli to facilitate access to the learning stimuli. Independent learning time was also embedded into the training procedure to promote rehearsal and consolidation of the new learning. It was unforeseen that some participants would have been unable to plan and organise their own learning time, however they were given close guidance by the researcher who introduced each of the tasks therefore such participants were given the same opportunity to complete tasks as all other participants. At the end of the final training session participants reviewed all 20 details of the vocabulary to reduce primary and recency effects. The assessment procedure provided the opportunity for participants to demonstrate their new learning despite spoken and / or written language difficulties.

6.5 THE EFFECTIVENESS OF THE COGNITIVE NEUROPSYCHOLOGY MODEL IN SUPPORTING THE MAIN INVESTIGATION AND ITS USEFULNESS AS A TOOL IN LEARNING STUDIES

A cognitive neuropsychology single word processing model (Ellis and Young, 1996; Kay, Lesser and Coltheart, 1992) was chosen as a method of recording and evaluating participant ability to learn the new vocabulary. The model is now discussed in relation to the requirements previously defined for recording and evaluating the learning of the new words (see section 2.9.3). Support and criticisms of the model's architecture for use in new learning studies are then discussed with reference to the literature.

6.5.1 Assess and evaluate the severity of aphasia

One of the requirements of the main investigation was that the chosen single word processing model would facilitate the assessment of the severity of each participant's language impairment. The pre-training language screening assessments employed a number of different tasks generally considered to target the various modules and pathways encompassed by the cognitive neuropsychology model (see Appendix 2.1). It was considered that the performance of participants on these language assessments provided adequate data about the abilities to process single words. This data was considered to differentiate participants in terms of severity of aphasia and indicated specific areas of difficulty for language comprehension and expression (spoken and written). However it must be noted that for some participants the extent of their language difficulties was not apparent with single word responses alone but was highlighted when connected speech was observed, for example in the narration of the Cinderella story. Therefore the cognitive neuropsychology approach was useful in identifying severity of aphasia in terms of single word processing rather than overall severity. However as the focus of the investigation was on single word acquisition and assessments only required single word responses it was considered appropriate and adequate for this investigation.

6.5.2 Support the methodology for learning procedure

The training procedure incorporated a number of approaches to facilitate the learning of the new vocabulary – pre-exposure and self-judgement techniques, which facilitated staggered learning of the new words and an errorless learning approach. Training tasks endeavoured to teach participants information about the new word forms and meanings in both spoken and written format, as well as their associations with already known words. The use of the cognitive neuropsychology model for these processes is described in Chapter 2 (see Figure 2i in 2.9.3) and Chapter 4 (see Figure 4ii and section 4.7). The model provided a useful architecture for the procedure and for the characteristics of the new vocabulary (for example, the pronunciation, spelling and syllable structure of the new word forms, and word meanings incorporating the visual image of the word and associated meanings of skills, habitat and food source). The model provided flexibility not only for spoken demonstration of the new vocabulary but also in other ways (such as word-picture and written syllable matching). This facilitated the demonstration of learning by participants unable to respond to assessments using either spoken or written format due to the severity of their aphasia.

6.5.3 Measurement of learning

Tasks relating to the cognitive neuropsychology model were used to establish baseline assessments as well as immediate and delayed assessments to demonstrate the learning and retention of the new vocabulary.

6.5.3.1 Baseline measures

Although the originality of the stimuli had been established in preliminary and pilot studies (see Chapter 3 and Chapter 4) it was important to obtain a baseline measure for learning to confirm the originality of the stimuli for participants. This involved a listening and reading recognition task and also enabled the practise of assessment tasks, thus reducing task artefact. These tasks also provided qualitative data, which informed the main investigation findings. For instance if participants could copy the written word and draw the creature image then it was assumed that they had adequate visuospatial skills for participation in the main investigation. Baseline measures also recorded when participants made false recognition responses for non-words and for such participants their performance on post-training recognition assessment tasks were noted with caution (for example, C11 who presented with false positives and negatives in both baseline and training assessment recognition tasks).

6.5.3.2 Facilitate the demonstration and measurement of new learning

Assessment tasks were devised for the main investigation, which also aimed to target the various modules and pathways of the cognitive neuropsychology model. These tasks facilitated the demonstration of learning for participants with severe spoken and / or written impairments. For instance, due to severe expressive aphasia C2 was only able to name four of the new words in spoken form (see section 5.7.2.1). If this were the only measure of new learning it would have suggested that he was unable to learn much of the vocabulary. However, C2 demonstrated this learning by naming all 20 of the new words in written format. C7 was unable to communicate in spoken or written format (see section 5.12.2) and was only able to demonstrate the spoken retrieval of three new words and none for written recall, suggesting that she had only learned three words. However C7 could match 11 new words (listening and reading) to their correct images and skills indicating that these new words were learned despite her being unable to say or write them. Convergent evidence of new learning was provided from a variety of assessment tasks in particular for cases where it was suspected that successful responses to target tasks could be through chance alone, in particular for low scoring participants. One such participant was C10 who recalled only 16% of information (raw score of 50 from a maximum total of 320) however she demonstrated that this information was learned rather than as a result of chance through accurately matching the new words with picture for five words (listening and reading), for three of these words she identified their skills and two of them she also identified their habitat and food.

6.5.4 Facilitate predictions for new learning by participants

As discussed, the single word processing abilities and difficulties of participants were identified using the pre-training language screening assessment tasks. Inferences were made regarding each participant’s particular presentation of aphasia in terms of alleged intact and impaired modules and pathways of the cognitive neuropsychological model. These were then mapped onto individual cognitive neuropsychology models to give a visual representation of their language processing abilities. This information was used to make predictions about anticipated difficulties that participants would encounter in learning the new word forms and / or word meanings as a result of their language impairment presentation. It was proposed that particular difficulties that participants would have with the new words would mirror their impaired performance with already familiar words. These predictions relating to the spoken and written responses of participants will now be discussed as well as some qualitative characteristics of their learning performance.

6.5.4.1 Spoken demonstration of learning

The pre-training language assessments identified both semantic and phonemic errors by participants on already familiar words as well as phonemic errors on non-words. It was predicted that error patterns of newly learned vocabulary would mirror those errors presented at baseline measures. Eleven participants presented with phonemic errors on non-words in the baseline tasks and the new words were also spoken with phonemic errors. However some participants made less phonemic errors on the new words. The presence of such target-related neologisms in the newly learned words is consistent with the literature which proposes that the representations of the new words would exist in a person's lexicon, however they would have difficulty accessing this representation. This suggests the creation of new representations despite the presence of phonemic errors due to difficulty accessing the full representation of the word form, similar to an exaggerated tip-of-the-tongue phenomenon encountered by adults without language impairment (Ellis and Young, 1996). Six participants presented with semantic errors on baseline language tasks and also presented with semantic errors relating to the newly learned information however errors were mainly on already familiar words (i.e. skills, habitat and food) rather than on the new words themselves. Word-finding difficulties were characteristics of nine participants on baseline language tasks and were also present in their performance on recalling the new words and associated skills as indicated by slow response time and the requirement for syllable cues to facilitate access for participants (for example C4 and C5).

6.5.4.2 Written demonstration of learning

The pre-training baseline language assessments identified significant difficulties by all participants in the written spelling of non-words. It was predicted that as the new words were initially non-words they would also therefore contain spelling errors. However, this was not the case for all participants, for example C1 had difficulty spelling non-words in baseline measures but made spelling errors on only three of the 20 new words, with those errors being closer to the target word than baseline spelling errors (see section 5.5.2.3). Participants P3 (see section 5.6.2.3), C2 (see section 5.7.2.3) and C3 (see section 5.8.2.3) also presented with this pattern. This reduction of errors (or elimination in C2's case) suggests a move from the new vocabulary being stored as non-words to real word status for some participants. It could also be interpreted as a written form of target-related neologisms suggesting that the new words had been learned but spelling errors reflected participants' difficulty accessing the new representation from the orthographic output lexicon (Ellis and Young, 1996) and where spelling errors did not occur it suggests that full word form representation was present and accessible. Another explanation could be the reflection of the fact that participants relied only on hearing the non-words for baseline measures but had both heard and seen the visual representations of the new words during the training session. It was not possible to differentiate the reason for the improved spelling as in order to follow the errorless learning approach participants were specifically not asked to attempt the spelling of the new words before training to avoid creating maladaptive connections.

6.5.4.3 Qualitative characteristics of learning

Pre-training language assessments captured a number of different characteristics of the spoken and written abilities of participants with aphasia. Eight participants presented with the lexicalisation of non-words at baseline measures during non-word repetition and reading tasks, for example, target – [fostəɹ], response = [fɔstəɹ] and target – [sbɪŋ], response = [sbɹɪŋ]. Six of these participants also lexicalised the newly learned words on occasion, for example, target – [sneɪtl], response = [sneɪl], target – [sɪlvaɹk], response = [sɪlvəɹ]. Overall participants were aware of these errors but unable to inhibit the familiar word responses or unable to offer alternatives. Although C1 and C6 made lexical errors on baseline measures they did not present with this characteristic for the newly learned words, suggesting perhaps that these words had well established lexical representations with strong activation patterns that did not compete with other similar lexical representations. Ellis and Young (1996) report rapid interaction between the phonological output lexicon and phonemic output buffer and when one or more of these pathways are impaired such errors occur. Although the corpus is small, these instances of non-word lexicalisation in the main investigation are consistent with the literature regarding phonological neighbourhood effects where phonologically related lexical items (usually considered to differ from the target word by one phoneme) are assumed to compete for lexical selection resulting in an incorrect choice of word (Gordon, 2002; Luce and Pisoni, 1998) and words with similar sounds are activated simultaneously interfering with lexical selection (Ellis and Young, 1996). Where participants presented with perseveration of phonemes or syllables in their responses to already familiar words (four participants) this was also a feature of their responses for the newly learned words.

6.5.5 Some support and criticisms of the cognitive neuropsychological model

The cognitive neuropsychological model proved useful for the current investigation, indicating that it is a robust method for identifying characteristics of new vocabulary learning at single word level, particularly for those individuals where spoken or written demonstration of this learning is hampered by phonological or orthographic impairment. One criticism of the cognitive neuropsychological model is that it is an off-line method of representing data, providing a snapshot of the single word processing abilities at one moment in time. The static nature of this model has also been criticised for its inability to represent components involved in the dynamic interactions of learning processes such as those in the developmental field (Thomas and Karmiloff-Smith, 2002). While the developmental process may initially seem divorced from the adult architecture this investigation has highlighted a parallel between the two, where the adult brain also continues to learn throughout its lifetime with related cortical plasticity (see sections 2.5 and sub-sections), including the creation of new language representations following damage (see Chapter 5 and section 6.2). However Jackson and Coltheart (2001) have defended the cognitive neuropsychological model for studying dynamic processes as it establishes what they term as the proximal cause of functional impairment, i.e. establishing the impairments of the cognitive system at this moment in time irrespective of the original cause. One challenge in advocating the cognitive neuropsychological approach for dynamic learning processes involves one of the core assumptions of the model that following damage to the cognitive system there is no substantial reorganisation or modification to the processing of unimpaired modules which are assumed to function normally (i.e. notion of transparency) (Coltheart, 1999). Rehabilitation investigations have indicated that this is not necessarily the case as in some instances it has been demonstrated using brain-imaging techniques that other parts of the brain (for example right hemisphere) take over the functions of the now damaged modules (Weiller et al., 1995) (see section 2.5.5). Another argument against this assumption is that compensatory techniques may modify the way unimpaired processes function following damage to the cognitive architecture (Johnston and Braisby, 2000). Cohen (2000) asserts that if rehabilitation involves the radical reorganisation of functions the transparency assumption of the cognitive neuropsychological model will not be upheld.

Another criticism of the cognitive neuropsychological model is that the architecture is not a complete theory in itself as the internal mechanisms of each module and how it communicates with other inter-related modules is unknown (Ellis and Young, 1996). The development of computational concepts may be one avenue to help explain the internal workings of the model through computer simulations (Cohen, 2000; Ellis and Young, 1996). Cognitive psychologists in using a connectionist approach attempt to build computerised models of cognition which are thought to have properties of neural information processing (Braisby and Gellatly, 2005). Cohen (2000) cautions however that while connectionist models have some properties in common with neurones they are not neuronal equivalent. Connectionist models are thought to operate at a level of learned automatic processes without conscious thought (Smolensky, 1988) and while damaged processing may be simulated it is not in itself a theory (McCloskey, 2004). However connectionist models provide insights into ways a damaged system could repair itself during recovery as it can model the learning process including loss of learning through damage and relearning during the recovery process (Cohen, 2000). The predictive power of connectionist modelling is thought to be enhanced due to the explanation of cognitive processing through learning (Lambon-Ralph, 2004).

While the cognitive neuropsychological approach cannot adequately capture the dynamic process of learning, it does inform the outcome of the learning procedure in terms of providing information about the depth and characteristics of knowledge acquired during the learning of skills (in this case language domain-specific in terms of learning new vocabulary).

6.5.6 Summary

The discussion in Chapter 2 identified a number of requirements that a suitable theoretical model of language would need to provide in order to be a useful tool for this investigation. A cognitive neuropsychology model was chosen and its usefulness in fulfilling the criteria for this investigation has been individually discussed with evidence above. The model provided a framework for assessing and evaluating the severity of each participant's presentation of aphasia. It supported the various tasks and procedures for the training sessions and the assessment procedure facilitating the measurement of baseline performance and the demonstration of new learning. Predictions were made for each participant on their performance on spoken and written tasks and error analysis facilitated predictions derived from qualitative data. All predictions for the learning characteristics of the new words were supported except where the new words became established as real words or strong representations in the lexicons of participants. An example of this was where participants had difficulty spelling non-words in baseline measures and it was predicted that the new words (originally non-words) would also contain spelling errors. This prediction was supported for many of the participants, however some participants demonstrated a marked reduction in the number of spelling errors with the new stimuli with closer responses to the target words than pre-training abilities for spelling non-words. This could be considered as a type of target-related neologism where representations of new words are established but not fully accessible. While the limitations of the cognitive neuropsychology model are acknowledged, particularly in terms of the dynamic process involved in learning, the model fulfilled the criteria for this investigation, i.e. to establish whether people with post-stroke aphasia could learn new language representations. While the findings of this investigation were not dependent on the validity of the model used, the cognitive neuropsychological model proved useful as an instrument to demonstrate change.

6.6 Clinical Relevance

The main investigation has established that young adults with post-stroke aphasia can learn new vocabulary despite residual language impairments. This knowledge has significant clinical relevance in terms of the development of a theory of rehabilitation and in relation to the procedures employed in the process of therapeutic intervention by speech and language therapists.

6.6.1 New learning

It has been established that despite cortical damage all 12 participants demonstrated some learning of the new vocabulary. As the literature indicates that learning invokes cortical plasticity (see section 2.5.2) and that this also occurs in brains damaged by stroke (see sections 2.5.3 and 2.5.4), the findings of this investigation suggest that cortical plasticity was likely to have occurred during the process of learning the new vocabulary. This suggestion of cortical plasticity related to new learning was supported not only by participants who recalled the new vocabulary without error but also those who made target-related neologisms in both spoken and written formats. These findings contribute to current knowledge about the rehabilitation of people with aphasia, and strongly suggest that language rehabilitation could incorporate the process of new learning where new synaptic connections and patterns are established. Therefore the process of aphasia rehabilitation may involve both the facilitation of accessing already held information or neuronal connections, which were inaccessible as a result of stroke as well as the process of new learning perhaps of previously known but now ‘forgotten’ words. Participants in the main investigation demonstrated that the newly learned vocabulary was retained in long-term memory for later retrieval indicating that appropriate approaches to language rehabilitation can induce long-term benefits.

In the main investigation participants with aphasia presented with a wide range of recovery stages spanning from five to 146 months post-stroke. Participants both in the acute and chronic stages of post-stroke recovery demonstrated the ability to learn new vocabulary. However the number of months post-stroke was significantly correlated to the learning of the new words suggesting that those participants in the acute stage of stroke did not learn as much information about the new words as those further along in their recovery. This implies that cortical plasticity may not only occur in the acute stages of stroke but also in the chronic stages. These findings are consistent with those studies that demonstrate the restitution of language by those people in the chronic stages of aphasia and refute the idea that language rehabilitation for those in the chronic stages of stroke should only incorporate compensation strategies rather than facilitation of further restitution of language.

6.6.2 Learning and aphasia rehabilitation

The findings from this investigation suggest that the rehabilitation process should draw on approaches and concepts of learning. The main investigation employed a number of different strategies from the literature on learning, which were successfully employed in the training of new vocabulary. This procedure has direct implications for a theory of rehabilitation and therapeutic approaches. The preliminary study findings highlighted the different learning styles of the normal population where participants had individual preferred learning methods, which did not appear appropriate for other participants' learning. Qualitative data indicated that the variation in learning methods used by participants with aphasia mirrored those used by the normal population. Theories and models have been developed which guide and inform the assessment process in defining the exact nature of language impairment. Without a theory to guide rehabilitation clinicians currently rely on clinical experience and single case studies to select appropriate therapeutic materials and approaches to facilitate the restitution of language. While single case studies have indicated that aphasia therapy is efficacious, clinicians are unable to predict which approaches or tasks would be most successful at targeting particular aspects of aphasia for rehabilitation. Additionally, they cannot explain why people with apparently similar characteristics of language impairment respond differently to rehabilitation efforts. The differing approaches by main investigation participants to learning the new vocabulary suggests that individuals approach the learning experience in different ways and choose methods most suited to their particular learning techniques, supporting the literature advocating single case studies. Therefore although the same stimuli might be used in rehabilitation, the differing approaches to learning may provide an explanation for the differences found in the recovery of aphasia. This information could be fundamental to the success of language rehabilitation in that problems in facilitating restitution of language may not be caused by the particular tasks employed but rather the manner in which they are presented to individual patients. Perhaps discovering the optimum learning strategy for each individual before embarking on the therapeutic process would identify the best methods and processes to use during their rehabilitation process. The use of learning concepts could revolutionise the rehabilitation of aphasia and promote the identification and establishment of optimum methods of learning to facilitate the highest potential restitution of language and thereby the reduction of any harmful or redundant therapy tools or methods, having a corresponding effect on the reduction of maladaptive neuronal connections. The incorporation of learning theory in future investigations could examine the constraining factors of new learning by people with aphasia, which appear to reflect the constraints experienced by those people whose language is not restored as completely as others.

The literature has demonstrated that without therapeutic intervention maladaptive cortical connections can be made (see section 2.5.4). The rehabilitation of aphasia may therefore be that structured experience-dependent process required for providing the optimal experiential guidance for language recovery. It has been previously suggested that language rehabilitation does not address this neurological level (Davis, 1993). However in order to eliminate such possible maladaptive cortical connections in the language area of the brain which would impact upon functional communication and possibly create connections that block or prevent further successful restitution, aphasia rehabilitation must begin to address the impact of its processes on the creation of neuronal connections. Learning approaches can provide further tools for addressing this in using, for example, the reduction of cognitive load on patients through the use of a staggered learning approach and the employment of an errorless learning paradigm in order to promote only accurate responses and inhibit impaired productions of speech. In addition the provision of time within language rehabilitation to rehearse and consolidate the stimuli, perhaps supported by errorless learning, may also promote accurate language restitution. Such approaches may contradict some therapeutic approaches where participants are encouraged to guess correct responses. However the danger of creating and strengthening maladaptive connections through repetition and rehearsal of incorrect responses can only serve to reduce the functional impact of therapy and the creation of patterns of accurate responses. Clinical studies have been supplemented and expanded by computer model approaches which have sought to mimic patterns of recovery observed in language rehabilitation and which in time could inform the language therapy process(es) (Harley, 2004; Robertson, 1999; Robertson and Murre, 1999).

6.6.3 Prognostic factors

The literature has identified a number of prognostic factors that are generally considered to impact upon the recovery of aphasia (see section 2.6). This investigation has also examined these factors in relation to the ability of people with aphasia to learn new vocabulary (see section 6.3). The same factors that affect the recovery from aphasia appear to affect the demonstration new vocabulary learning. These factors could be considered when assessing the potential of individuals to recover from aphasia. Additionally, where language recovery appears to have reached a plateau in individuals (i.e. progress ceases), it may be important to identify such factors that may be contributory elements impeding further language restitution. Identification of those factors that affect both recovery from aphasia and new learning for specific individuals could encourage clinicians to address particular difficulties before embarking upon language rehabilitation, for example depression and anxiety, attention, memory and executive functions. A number of factors will now be described in terms of the impact that they could have for clinicians during the rehabilitation process.

The group trend of this investigation indicated that younger participants could learn more new vocabulary than older ones and this was consistent with the literature on recovery of aphasia (see section 2.6.1.1). However as this was not true for all participants (for example P3, see section 5.3.2.1) clinicians should not assume that older participants do not have potential for language restitution. Education was identified as a significant factor in the acquisition of new vocabulary however those individuals with low levels of education cannot be excluded from rehabilitation. Perhaps it would be more appropriate to consider individual abilities on a single case study basis in order to inform the best therapy methods for each person. The experience of education, for example, appears to teach a person the skills of learning that less educated people do not learn. Perhaps the teaching of learning skills is something that should be incorporated into the rehabilitation process prior to direct language rehabilitation in order to optimise the therapeutic experience and therefore language restitution.

Clinicians should also take into consideration that severity of aphasia is a significant factor in language recovery as well as new learning and may be linked to biological limitations, which may indicate insufficient surviving neurones for cortical plasticity to occur in the damaged language domain. It was speculated that if participants could not demonstrate the general capacity to learn then they would also not be able to learn in a specific domain such as language. However statistically, participant capacity to learn the non-linguistic task did not predict their learning ability in the language domain. It was noted however that two participants who were unable to complete the non-linguistic task also learned the least amount of new vocabulary. Perhaps a larger data set or more sensitive or more complex non-linguistic learning tasks would provide further information on this point.

The intensity and timing of therapeutic intervention is a controversial topic. This investigation supports previous studies which advocate the significance of cortical plasticity in people in the chronic stages of recovery but has also indicated that those in the more acute stages of stroke also demonstrate new synaptic connections despite the brain recovering from the trauma of stroke. This study employed an intensive training regime over a period of four days and findings are consistent with the literature that advocates the benefits of intensive training. National clinical guidelines in Scotland (SIGN, 2002) advocate that where individuals are well and motivated enough that they receive a minimum of two hours of speech and language therapy per week however, this does not appear to be the general experience of NHS patients. As suggested by Meinzer et al. (2002), alternative options could involve training carers or perhaps use computer-based training programmes to provide daily intensive therapy in people's own homes.

Speculation about the impact of various prognostic factors highlights the requirement of caution for clinicians. In particular group trends indicate that individuals with the best prognosis for language restitution are young, well educated perhaps in a highly skilled occupation and with intact cognitive abilities. Does this suggest therefore that all other individuals should be refused language rehabilitation? Firstly, it is not often that someone would present with such a profile following a stroke. Secondly and more importantly, analysis of the individual data indicates that the group trends are not true for all individuals in the investigation. Caution should therefore be advised regarding blanket statements from group studies and supports those advocates of single case studies or case series over randomised control trials and other group studies for the investigation of people with post-stroke aphasia. Additionally, perhaps the therapeutic process should be patient driven rather than therapist driven and a more flexible approach to individual participation in language therapy be established.

6.7 EVALUATION OF THE INVESTIGATION

This investigation was original and therefore the stimuli and methodology had to be developed. The novel stimuli were created by the researcher and incorporated novel word forms with novel meanings as well as associations to already familiar words. The British National Corpus (1998) and 75 adults from the normal population established that these new words were original and unique. These stimuli were not only unique for the main investigation but is also the first new vocabulary that has been reportedly used to evaluate the capacity of adults with aphasia to learn new vocabulary. This had been a methodological issue with previous learning investigations with this population (see sections 2.8.6 and 2.9.1). The training methodology was based on optimum methods of learning from published research, in particular pre-exposure of stimuli providing a staggered learning experience, imagery techniques in the form of self-judgement tasks and tasks based on the concept of errorless learning (see section 2.9.2). Previous studies used different methods of evaluating learning with some of them employing spoken and/or written responses alone. However this investigation employed a range of assessments to facilitate the demonstration of learning particularly by those participants unable to respond in spoken and /or written formats. The results suggested that the assessment tasks used to evaluate new vocabulary learning were sensitive enough not to disadvantage non-verbal participants (see Table 5.2 and sections 5.3, 5.17). The preliminary and pilot studies provided a robust evaluation of the stimuli and methodology and provided opportunity for enhancing the training and assessment procedure. Another strength of this investigation was the provision of an overview of a wide range of possible influencing factors that affected the learning of the new vocabulary. The lack of detail in cognitive assessments is acknowledged however these analyses were secondary to the main focus of the investigation, which was to establish the ability of adults with aphasia to learn new representations of language. Twelve participants took part in the main investigation with no attrition throughout the training and assessment procedure. Ten participants further took part in delayed recall assessments enabling the assessment of the retention of this initial learning 3-5 days following training. While twelve participants may be considered small in number it was successful recruitment for this type of study and was sufficient to answer the main research question. However a larger population would facilitate more powerful statistics. As already discussed this research is novel, the findings of which provide many areas of opportunity for further research. Suggestions for future research will now be discussed.

6.8 SUGGESTIONS FOR FUTURE RESEARCH

The main investigation involved a case series of 12 participants with post-stroke aphasia. The collected data was analysed and established that people with language impairment could learn new vocabulary despite varying severities of aphasia. A large-scale replication of this research would increase the dataset and provide additional information regarding the learning abilities of the aphasic population. Individual participant data in this investigation supports the requirement for single case study reporting, however a larger sample may identify aspects of new learning that could inform the general aphasic population rather than reflecting individual idiosyncrasies. A larger sample would also enable more powerful statistical analyses of the data in consideration of the various factors found to impact upon the ability to learn the new vocabulary.

Further statistical analyses with a larger sample may enable the interacting influential factors to be fractionated to determine which factors impact most on the learning of new vocabulary.

The provision of more detailed biological and neurological information with a larger population would also allow for analyses of the biological limitations to learning new vocabulary and related cortical plasticity. Additionally, the impact of type of stroke (i.e. infarct versus haemorrhage) could be analysed in relation to the number of new words learned. The use of brain-imaging techniques could determine the location and severity of neurological damage and identify the extent and location of cortical reorganisation following training, thus further contributing to knowledge of the abilities and mechanisms involved in the damaged brain learning new vocabulary. Findings may indicate new ways of approaching the rehabilitation of such language impairments. The social impact and influence on recovery should be considered such as family, active engagement, return to work and emotional disturbances as a result of the biological and psychological effects of the stroke. Close liaison with the multidisciplinary team is recommended in order to reduce the impact of such factors on rehabilitation, particularly where depression is involved which has a temporary and reversible impact on language and cognitive functioning.

In this investigation participants were trained on five words per day for four days and each day had a maximum of 30 minutes to consolidate this learning. The investigation indicated that participants had different learning styles and pre-morbid experience in learning skills. The lower scoring participants also had less education and subsequently may have been less skilled in learning strategies and techniques. Any further investigation should ensure that all participants were given some time pre-training to explore their particular learning techniques. In addition to learning techniques, participants may have different learning processes where some people can memorise information more quickly than others. It would be useful to ascertain if intensive learning of the vocabulary would increase the performance of those low scoring participants where they would learn fewer words over the same period of time (four days) or have a longer period of time to learn the same set of items. This information would further inform therapy as to the different ways that patients interact with the rehabilitation process and highlight methods of ensuring that each individual is given the opportunity for optimal restitution of language before resorting to alternative communication methods. The impact of cognitive impairments on the acquisition of new vocabulary has been highlighted, however more in-depth assessments that are sensitive for people with aphasia are required for future research. Large-scale investigations that assess the effects of therapeutic intervention of cognitive impairment in people with aphasia and in particular in relation to language rehabilitation would be invaluable in informing the rehabilitation of aphasia.

All participants in the main investigation demonstrated the ability to learn in the language domain. This suggests that new learning could be part of the underlying process of language rehabilitation. If so, this has implications for speech and language therapists. Further investigations could ascertain if it is possible to teach people the best method for learning, particularly those individuals with limited education experience. If so, the impact of success of therapeutic rehabilitation could be evaluated following such training and findings would inform the best therapy methods to adapt. In addition, as this investigation has demonstrated the ability of people with aphasia to learn new vocabulary, is the possibility of adapting therapy methods to promote new learning, which would be invaluable for speech and language therapists.

The main investigation employed new single words in the form of common nouns. When new vocabulary is learned it is then extended from single word practise and incorporated into connected speech. Further investigation would extend the examination of the ability to learn new vocabulary in isolation to analysing how these words would be incorporated into connected speech and the factors that may impact upon their use. Additionally, new vocabulary in the form of verbs could be examined and compared to the ability to learn and use common nouns. This would be of particular of interest for those people with grammatical impairments as a result of their stroke.

6.9 SUMMARY AND CONCLUSIONS

At present there is no complete theory of rehabilitation in the language domain and it is not known if aphasia rehabilitation could incorporate new learning or if the rehabilitation merely involved facilitating the accessing of previously known but inaccessible memory traces. To begin to address this, people with post-stroke aphasia must be able to demonstrate that they can learn new language related material. Prior to this investigation this was not known. While previous studies had demonstrated that people with aphasia have the general ability to learn, these studies involved paired stimuli with a familiar and matched novel component. The main aim of this investigation was bridge this gap in current knowledge and to establish if adults with post-stroke aphasia could demonstrate new learning in the language domain.

As the investigation was original, the stimuli and procedure had to be designed and were evaluated during rigorous preliminary and pilot studies (see Chapter 3 and Chapter 4). The outcome was a vocabulary set of 20 new words encompassing novel word forms and novel meanings that were related to already known words in the participants' vocabularies. The methodology of the investigation incorporated procedures based on evidence from the literature where possible, in order to facilitate and promote optimum learning by participants. Similar to the stimuli, the training procedure was developed, evaluated and amended (when required) through the preliminary and pilot studies using normal and post-stroke participants (non-aphasic and aphasic).

Fourteen participants were recruited for the main investigation from local speech and language therapists, young stroke groups and local college. Participant attrition involved two participants – one due to ill-health and one as a result of visual difficulties that impaired her ability to use the stimuli. Twelve participants took part in the main investigation, ten of whom also participated in delayed recall assessment tasks. Participant age ranged between 33;11-64;04 years. Participants also presented with a wide range of years in education (9-21.5 years), level of occupation (homemaker to pharmacist), severity of aphasia and cognitive abilities (mild to severely impaired) and were at different stages of recovery from their stroke (5-146 months post-stroke). Immediate recall scores revealed a range of learning abilities from the highest recall score of 99% to the lowest of 15% of information about the new words in terms of word form, word meaning and associated meanings. All ten participants retained some information about the new vocabulary at delayed recall with the highest recall score being 82% and the lowest of 17.5%. When the immediate and delayed recall scores were compared it was noted that participants retained from 49% to 83% of information from the training sessions. Qualitative data revealed similarities in errors made by the normal and aphasic population and also errors made by the aphasic population alone, suggesting the impact of factors other than normal variation on learning the new vocabulary (see section 5.3.1). Factors that are thought to affect the restitution of language function (see section 2.6) were examined to ascertain if they also impacted upon the ability to learn new vocabulary using Hierarchical Cluster analyses and Correlation statistics (see section 5.18 and sub-sections). The findings revealed that some of those factors that influence the recovery of language function also impact upon the ability to make new language representations, in particular, personal attributes, cognitive functioning (with the exception of the non-linguistic learning task), severity of aphasia and amount of time spent rehearsing and consolidating the new learning. The group trends suggested that the individual most likely to recover from aphasia was a young, well-educated person, and possibly in a high occupation level who was able to plan and organise their own learning time. However individual case studies advise caution, as the group trends were not true for all participants. This highlighted the heterogeneity of the aphasic population and advocated the use of case studies or case series rather than group studies when investigating this population.

This investigation has now established that adults under the age of 65 years can learn new vocabulary despite a range of severity of post-stroke aphasia and at various stages of their recovery. However there are still many questions unanswered. While the population sample was small it was adequate to answer the question whether new learning was possible with the aphasic population. However a larger sample would facilitate more powerful quantitative and richer qualitative analyses. This investigation evaluated the ability of participants to learn single words therefore further investigations are required which assess the ability of using new representations in conversational speech and compare perhaps the ability to learn and use other word classes for example, verbs. The demonstration of new learning by participants suggests that cortical plasticity related to new learning may have occurred in this investigation. Future studies could incorporate brain-imaging techniques to observe the impact of the extent and location of lesions on the ability to learn the new vocabulary in addition to the extent and location of cortical plasticity related to the acquisition of new representations of language. The findings have direct implications for the rehabilitation of language functioning. Firstly, future studies could ascertain if those lower scoring participants could learn more vocabulary if given fewer words to learn over the same period (i.e. four days) or if learned over a longer time period. The possibility of teaching people the best methods to learn new vocabulary and their impact on new learning needs to be investigated as this would directly impact upon speech and language therapy intervention techniques. In addition, speech and language therapists would need to consider the adaptation of therapy tools and methods in order to promote new learning processes in therapy.

In conclusion, this investigation has established that adults with aphasia can learn new language representations in the form of new vocabulary despite a range of severity of aphasia and other influencing factors. This information needs to be considered in future rehabilitation efficacy studies in terms of methodology. Further investigations are required to contribute to the development of a theory of language rehabilitation with a view to providing people with aphasia with the best opportunity for the restitution of language functioning.

References

Alexander, M. P. (1994) Stroke rehabilitation outcome: a potential use of predictive variables to establish levels of care. *Stroke*, vol.25; 128-134.

Anderson, M. (2001) Annotation: conceptions of intelligence. *Journal of Child Psychology and Psychiatry*, vol. 42 (3); 287-298.

Anderson, C. S., Linto, J. and Stewart-Wynne, E. G. (1995) A population-based assessment of the impact and burden of caregiving for long-term stroke survivors. *Stroke*, vol. 26; 843-849.

Arkin, S. M., Rose, C., and Hopper, T. (2000) Implicit and explicit learning gains in Alzheimer's patients: effects of naming and information retrieval training. *Aphasiology*, vol. 14 (7); 723-742.

Artes, R. and Hoops, R. (1976) Problems of aphasic and nonaphasic stroke patients as identified and evaluated by patients' wives. In *Recovery in aphasics,* Y. Lebrun, ed., Swets and Zeitlinger B V, Amsterdam; 31-45.

Åström, M., Adolfsson, R., and Asplund, K. (1993) Major depression in stroke patients. *Stroke,* vol. 24; 976-982.

Baddeley, A. and Wilson, B. (1994) When implicit learning fails: amnesia and the problem of error elimination. *Neuropsychologia*, vol. 32 (1); 53-68.

Bagg, S., Pombo, A. P. and Hopman, W. (2002) Effect of age on functional outcomes after stroke rehabilitation. *Stroke*, vol. 33; 179-185.

Basso, A. (2002) Language therapy: does it help?
www.cf.ac.uk/psych/ercd/speak/abstracts/basso.html

Basso, A. (1992) Prognostic factors in aphasia. *Aphasiology*, vol.6 (4); 337-348.

Basso, A. (1989) Spontaneous recovery and language rehabilitation. In X. Seron and G. Deloche (Eds) *Cognitive approaches in neuropsychological rehabilitation*, Lawrence Erlbaum Assoc. London.

Basso, A. and Caporali, A. (2001) Aphasia therapy or the importance of being earnest. *Aphasiology*, vol. 15 (4); 307-332.

Basso, A., Marangolo, P., Piras, F., and Galluzzi, C. (2001) Acquisition of new "words" in normal subjects: a suggestion for the treatment of anomia, *Brain and Language*, vol. 77; 45-59

Bayles, K. A. (2001) Understanding the neuropsychological syndrome of dementia. *Seminars in speech and language*, vol. 22 (4); 715-728.

Beauvois, M. F. (1982) Optic aphasia: a process of interaction between vision and language. *Philosophical Transactions of the Royal Society of London*, B (289); 35-47.

Beblo, T., Baumann, B., Bogerts, B., Wallesch, C. W., and Herrmann, M. (1999) Neuropsychological correlates of major depression: a short term follow-up. *Cognitive Neuropsychiatry,* vol. 4; 333-341.

Becker, J. T., MacAndrew, D. K., and Fiez, J. A. (1999) A comment on the functional localization of the phonological storage subsystem of working memory. *Brain and Cognition,* vol. 41; 27-38.

Best, W. and Nickels, L. (2000) From theory to therapy in aphasia: where are we now and where to next? *Neuropsychological Rehabilitation*, vol. 10(3); 231-247.

Bhogal, S. K., Teasell, R. and Speechley, M. (2003) Intensity of aphasia therapy, impact on recovery. *Stroke*, vol. 34; 987-993.

Bjork, E. L. and Bjork, R. A. (1996) Continuing influences of to-be-forgotten information. *Consciousness and Cognition v*ol. 5; 176-196.

Black, M. and Chiat, S. (2003) *Linguistics for clinicians*. Oxford University Press. London.

Boardmaker Picture Index (1996) *The Picture Communication Symbols*. Mayer-Johnson Co.

Bolla-Wilson, K., Robinson, R. G., Starkstein, S. E., Boston, J. and Price T.R. (1989) Lateralization of dementia of depression in stroke patients. *American Journal of Psychiatry, v*ol. 146 (5);627-634.

Boyle, M. (1999) What's in a name? not much is it's not well defined. *Aphasiology*, vol.13 (2); 132-134.

Braisby, N. and Gellatly, A. (2005) Foundations of cognitive psychology. In N. Braisby and A. Gellatly (Eds) *Cognitive Psychology*. Open University Press. Milton Keynes.

Breedin, S. D., Saffran, E. M. and Schwartz, M. F. (1998) Semantic factors in verb retrieval: an effect of complexity. *Brain and Language*, vol. 63 (1); 1-31.

Brindley, P., Copeland, M., Demain, C. and Martyn, P. (1989) A comparison of the speech of ten chronic Broca's aphasics following intensive and non-intensive periods of therapy. *Aphasiology*, vol.3 (8);695-707.

British National Corpus (1998) http://info.ox.ac.uk/bnc/corpora.html accessed 2001

Bryan, K., Jordan, L., Lock, S., Maxim, J., O'Kelly, D., and Gambrell, E. (2003) Different strokes work after stroke project. http://www.differentstrokes.org.uk

Buell, S. J. and Coleman, P. D. (1981) Quantitative evidence for selective dendritic growth in normal human aging but not in senile dementia. *Brain Research,* vol.214;23-41.

Burgio, F. and Basso, A. (1997) Memory and aphasia. *Neuropsychologia*, vol. 35 (6); 759-766.

Butfield, E. and Zangwill, O. L. (1946) Re-education in aphasia: a review of 70 cases. *Journal of Neurology, Neurosurgery and Psychiatry*, vol. 9; 75-79.

Bütefisch, C. M., Hummelsheim, H., Denzler, P., and Mauritz, K. H. (1995) Repetitive training of isolated movements improves the outcome of motor rehabilitation of the centrally paretic hand. *Journal of the Neurological Sciences*, vol. 130; 59-68.

Byng, S. (1993) Hypothesis testing and aphasia therapy. In A. Holland and M. Forbes (Eds) *World perspectives on aphasia*. Singular Press. San Diego CA.

Byng, S. and Black, M. (1995) What makes a therapy? some parameters of therapeutic intervention in aphasia. *European Journal of Disorders of Communication*, vol. 30; 303-316.

Byng, S. and Black, M. (1989) Some aspects of sentence production in aphasia. *Aphasiology*, vol. 3 (3); 241-263.

Callahan, C. D. (2001) The assessment and rehabilitation of executive function disorders. In Johnstone, B. and Stonnington, H. H. (Eds) *Rehabilitation of neuropsychological disorders*. Psychology Press, Hove.

Candia, V., Schafer, Th., Taub, E., Rau, H., Altenmüller, E., Rockstroh, B. and Elbert, T. (2002) Sensory motor retuning: a behavioral treatment for focal hand dystonia of pianists and guitarists. *Archive Phys Med Rehabilitation*, vol. 83; 1342-1348.

Candia, V., Elbert, T., Altenmüller, E., Rau, H., Schafer, T. and Taub, E. (1999) Constraint-induced movement therapy for focal hand dystonia in musicians [letter]. *Lancet*, vol. 353 (9146):42

Capitani, E., Laiacona, M., Mahon, B. and Caramazza, A. (2003) What are the facts of semantic category-specific deficits? A critical review of the clinical evidence. *Cognitive Neuropsychology*, vol. 20 (3/4/5/6); 213-261.

Cappa, S. F. (2000) Neuroimaging of recovery from aphasia. N*europsychological Rehabilitation*, vol. 10(3); 365-376.

Carnwath, T. C. M. and Johnson, D. A. W. (1987) Psychiatric morbidity among spouses of patients with stroke. *British Journal of Medicine*, vol. 294; 409-411.

Caramazza, A. (1998) The interpretation of semantic category-specific deficits: what do they reveal about the organization of conceptual knowledge in the brain? *Neurocase*, vol. 4; 265-272.

Caramazza, A. and Hillis, A. E. (1991) Lexical organisation of nouns and verbs in the brain. *Nature*, vol. 349; 788-790.

Caramazza, A., Hillis, A. E., Rapp, B. C. and Romani, C. (1990) Multiple semantic or multiple confusions? *Cognitive Neuropsychology*, vol. 7; 161-168.

Christensen, A. (1997) Communication in relation to self-esteem. *Aphasiology*, vol. 11(7); 727-734.

Clare, L., Wilson, B., Breen, K. and Hodges, J. R. (1999) Errorless learning of face-name associations in early Alzheimer's disease, *Neurocase*, vol. 5 (1); 37-46.

Classen, J. (2003) Focal hand dystonia – a disorder of neuroplasticity? *Brain*, vol. 126;2571-2572.

Code, C. (2003) The quantity of life for people with chronic aphasia. *Neuropsychological Rehabilitation*. 13 (3); 379-390.

Code, C. and Herrmann, M. (2003) The relevance of emotional and psychosocial factors in aphasia to rehabilitation", *Neuropsychological Rehabilitation*, vol. 13(1/2); 109-132.

Code, C., Hemsley, G. and Herrmann, M. (1999) The emotional impact of aphasia. *Seminars in speech and language*, vol. 20 (1); 19-31.

Cohen, G. (2000) Overview. In G. Cohen, R. A. Johnston and K. Plunkett (Eds) *Exploring cognition: damaged brains and neural networks*. Psychology Press. Hove.

Coltheart, M. (1999) Modularity and cognition. *Trends in Cognitive Sciences*, vol. 3; 115-120.

Cornelissen, K., Laine, M., Tarkiainen, A., Jarvensivu, T., Martin, N. and Salmelin, R. (2003) Adult brain plasticity elicited by anomia treatment. *Journal of Cognitive Neuroscience,* vol. 15 (3); 444-461.

Curtiss, G., Vanderploeg, R. D., Spencer, J. and Salazar, A. M. (2001) Patterns of verbal learning and memory in traumatic brain injury. *Journal of the International Neuropsychological Society*, vol. 7 (5); 574-585.

Daniele, A., Giustolisi, L., Silveri, M.C., Colosimo, C. and Gainotti, G. (1994) Evidence for a possible neuroanatomical basis for lexical processing of nouns and verbs. *Neuropsychologia, vol.* 32; 1325-1341.

Darley, F.L. (1982) *Aphasia*. W. B. Saunders. P. A. Philadelphia.

Darley, (1972) The efficacy of language rehabilitation in aphasia. *Journal of speech and hearing disorders*, vol. 37; 3-21.

Davis, G. A. (1993) *Principles of treatment. A survey of adult aphasia and related language disorders*. Prentice-Hall. Englewood Cliffs, N. J.

Dawson, D. R. and Chipman, M. (1995) The disablement experienced by traumatically brain-injured adults living in the community. *Brain Injury*, vol. 9; 339-353.

Deary, I. J. (2001*) Intelligence: a very short introduction*. Oxford University Press. New York.

de Groot, A. M. B. and Kiejzer, R. (2000) What is hard to learn is easy to forget: The roles of word concreteness, cognate status, and word frequency in foreign-language vocabulary learning and forgetting. *Language Learning*, vol. 50 (1); 1-56.

de Riesthal, M. and Wertz, R. T. (2004) Prognosis for aphasia: relationship between selected biographical and behavioural variables and outcome and improvement. *Aphasiology,* vol. 18 (10); 899-915.

Doesborgh, S. J. C., van de Sandt-Koenderman, W. M. E., Dippel, D. W. J., van Harskamp, F., Koudstaal, P. J., and Visch-Brink, E. G. (2002) The impact of linguistic deficits on verbal communication. *Aphasiology*, vol.16 (4/5/6); 413-423.

Downes, J. J., Kalla, T., Davies, A. D. M., Flynn, A., Ali, H., and Mayes, A. R. (1997) The pre-exposure technique: a novel method for enhancing the effects of imagery in face-name association learning. *Neuropsychological Rehabilitation*, vol. 7(3); 195-214.

Elbert, T., Candia, V. Altenmüller, E., Rau, H., Sterr, A., Rockstroh, B., Pantev, C. and Taub, E. (1998) Alteration of digital representations in somatosensory cortex in focal hand dystonia. *NeuroReport,* vol. 9; 3571-3575.

Elbert, T., Pantev, C., Weinbruch, C., Rockstroh, B., and Taub, E. (1995) Increased cortical representation of the fingers of the left hand in string players. *Science,* vol. 270; 305-307.

Ellis-Hill, C. S. and Horn, S. (2000) Change in identity and self-concept: a new theoretical approach to recovery following a stroke. *Clinical Rehabilitation*, vol. 14; 279-287.

Ellis, A. W. and Young, A. W. (1996) *Human cognitive neuropsychology.* Psychology Press, Hove.

Enderby, P. and Emerson, J (1995) *Does speech and language therapy work? A review of the literature*. Whurr Publishers Ltd. UK.

Enderby, P. and Petheram, B. (2002) Has aphasia therapy been swallowed up? *Clinical Rehabilitation*, vol. 16; 604-608.

Evans, J. J., Wilson, B. A., Schuri, U., Andrade, J., Baddeley, A., Bruna, O., Canavan, T., Della Sala, S., Green, R., Laaksonen, R., Lorenzi, L., and Taussik, I. (2000) A comparison of "errorless" and "trial-and-error" learning methods for teaching individuals with acquired memory deficits. *Neuropsychological Rehabilitation,* vol. 10 (1); 67-101.

Ferguson, A. (1999) Learning in aphasia therapy: it's not so much what you do, but how you do it! *Aphasiology,* vol. 13 (2); 125-132.

Fifer, W. P. and Moon, C. M. (1994) The role of mother's voice in the organization of brain functions in the newborn. *Acta Paediatrica*, vol. 83; 86-93.

Fillingham, J. K., Sage, K. and Lambon Ralph, M. A. (2005) Treatment of anomia using errorless versus errorful learning: are frontal executive skills and feedback important? *International Journal of Language and Communication Disorders*, vol. 40 (4); 505-523.

Fillingham, J. K., Hodgson, C., Sage, K. and Lambon Ralph, M. A. (2003) The application of errorless learning to aphasic disorders: a review of theory and practice. *Neuropsychological Rehabilitation,* vol. 13 (3); 337-363.

Fowler, H. W. and Fowler, F. G. (1990) *The concise oxford dictionary*. 8th Edition by R. E. Allen. BCA. London.

Frattali, C. M. (1998) Outcomes measurement: definitions, dimensions and perspectives. In *Measuring outcomes in speech-language pathology* C. M. Frattali (Ed), Thieme, New York; 1-27.

Freed, D. B., Marshall, R. C., and Phillips, D. S. (1998) Comparison of semantically and phonemically based training procedures in an overlearned naming task. *Perceptual and Motor Skills*, vol. 87; 795-800.

Freed, D. B., Marshall, R. C., and Nippold, M. A. (1995) Comparison of personalized cueing and provided cueing on the facilitation of verbal labelling by aphasic subjects. *Journal of Speech and Hearing Research*, vol. 38; 1081-1090.

Gainotti, G. (1997) Emotional, psychological and psychosocial problems of aphasic patients: an introduction. *Aphasiology*, vol. 11 (7); 635-650.

Garcia, L. J., Barrette, J., and Laroche, C. (2000) Perceptions of the obstacles to work reintegration for persons with aphasia. *Aphasiology*, vol. 14(3); 269-290.

Glosser and Goodglass (1990) Disorders in executive control functions among aphasic and other brain-damaged patients. *Journal of Clinical and Experimental Neuropsychology*, vol. 12; 485-501.

Gordon, J. K. (2002) Phonological neighborhood effects in aphasic speech errors: spontaneous and structured contexts. *Brain and Language*, vol. 82; 113-145.

Gordon, J. K. (1999) Can learning theory teach us about aphasia therapy? *Aphasiology*, vol.13 (2); 134-140.

Greener, J., Enderby, P. and Whurr, R. (2005) Speech and language therapy for aphasia following stroke. *Cochrane Database of Systemic Reviews (3),* Cochrane Stroke Group.

Grossberg, S. (1999) The link between brain learning, attention, and consciousness. *Consciousness and Cognition*, vol. 8; 1-44.

Grossman, M. and Carey, S. (1987) Selective word-learning deficits in aphasia. *Brain and Language*, vol. 32; 306-324.

Harley, T. (2004) Does cognitive neuropsychology have a future? *Cognitive Neuropsychology*, vol. 21 (1); 3-16

Harley, T. (2001) *The psychology of language: from data to theory*. 2nd Edition. Psychology Press. Hove.

Hebb, D. O. (1949) *The organization of behaviour: a neuropsychological theory* Wiley, New York.

Helm-Estabrooks, N. (2002) Cognition and aphasia: a discussion and a study. *Journal of Communication Disorders*, vol. 35(2); 171-186.

Helm-Estabrooks, N. (2001) *Cognitive Linguistic Quick Test*. The Psychological Corporation. USA.

Helm-Estabrooks, N. (1998) A cognitive approach to treatment of an aphasic patient. In N. Helm-Estabrooks and A. L. Holland (Eds) *Approaches to the treatment of aphasia*. San Diego, CA: Singular.

Herrmann, M. (1997) Studying psychosocial problems in aphasia: some conceptual and methodological considerations. *Aphasiology*, vol. 11(7); 717-725.

Herrmann, N., Black, S. E., Lawrence, J., Szekely, C. and Szalai, J. P. (1998) The sunnybrook stroke study: a prospective study of depressive symptoms and functional outcome. *Stroke*, vol. 29; 618-624.

Herrmann, M. and Wallesch, C. W. (1990) Expectations of psychosocial adjustment in aphasia: A MAUT study with the Code-Müller scale of psychosocial adjustment. *Aphasiology*, vol. 4; 527-538.

Hesse, S., Bertelt, C., Jahnke, M. T., Schaffrin, A., Baake, P., Malezie, M., and Mauritz, K. H. (1995) Treadmill training with partial body weight support compared with physiotherapy in nonambulatory hemiparetic patients. *Stroke*, vol. 26 (6); 976-981.

Hillis, A. E. and Heidler, J. (2002) Mechanisms of early aphasia recovery. *Aphasiology*, vol. 16 (9); 885-895.

Hillis, A. E. and Caramazza, A. (1991) Category-specific naming and comprehension impairment: a double dissociation. *Brain*, vol.114; 2081-2094.

Hillis, A. E., Rapp, B., Romani, C. and Caramazza A. (1990) Selective impairments of semantics in lexical processing. *Cognitive Neuropsychology*, vol. 7; 191-243.

Hinckley, J. J. (2002) Vocational and social outcomes of adults with chronic aphasia. *Journal of Communication Disorders*, vol. 35; 543-560.

Hinckley, J. J. (1998) Investigating the predictors of lifestyle satisfaction among younger adults with chronic aphasia. *Aphasiology*, vol. 12 (7/8); 509-518.

Hodges, J. R. and Greene, J. D. W. (1998) Knowing about people and naming them: can alzheimer's disease patients do one without the other? *Journal of Experimental Psycholog*y, vol. 51 (7); 121-134.

Hoffman, M. (2001) Higher cortical function deficits after stroke: an analysis of 1,000 patients from a dedicated cognitive stroke registry. *Neurorehabilitation and Neural Repair*, vol. 15(2); 113-127.

Holland, A.L., Greenhouse, J. B., Fromm, D. and Swindell, C. S. (1989) Predictors of language restitution following stroke. A multivariate analysis. *Journal of speech and hearing research*, vol. 32; 232-238.

Hopman, W. M. and Verner, J. (2003) Quality of life during and after inpatient stroke rehabilitation. *Stroke*, vol. 34; 801-805.

Horner, J., Loverso, F. L. and Rothi, L. G (1994) Models of aphasia treatment. In R. Chapey (Ed.) *Language intervention strategies in adult aphasia*. Williams and Wilkins. Baltimore;135-145.

Horton, S. and Byng, S. (2000) Examining interaction in language therapy. *International Journal of Language and Communication Disorders*, vol. 35 (3); 355-375.

House, A., Dennis, M., Warlow, C., Hawton, K. and Molyneaux, A. (1990) The relationship between intellectual impairment and mood disorder in the first year after stroke. *Psychological Med*, vol. 20; 805-804.

Howard, D. (1999) Learning theory is not enough. *Aphasiology,* vol.13 (2); 140-143.

Howard and Hatfield (1987) *Aphasia Therapy. Historical and contemporary issues*. Hillsdale NJ: Lawrence Erlbaum Associates.

Hunkin, N. M., Squires, E. J., Aldrich, F. K., and Parkin, A. J. (1998) Errorless learning and the acquisition of word processing skills. *Neuropsychological Rehabilitation*, vol. 8(4); 433-449.

Hunter, J. P., Katz, J., and Davis, K. D. (2003) The effect of tactile and visual sensory inputs on phantom limb awareness. *Brain*, vol. 126; 579-589.

ICF (2001) *International classification of functioning, disability, and health: ICF*, World Health Organisation, Geneva.

Jackson, N. E. and Coltheart, M. (2001) *Routes to reading success and failure: toward an integrated cognitive psychology of atypical reading*. Psychology Press.

Jacobs, B. and Scheibel, A. B. (1993) A quantitative dendritic analysis of Wernicke's area in humans. I. Lifespan changes. *The Journal of Comparative Neurology*, vol. 327; 83-96.

Jacobs, B., Schall, M., and Scheibel, A. B. (1993) A quantitative dendritic analysis of Wernicke's area in humans. II. gender, hemispheric and environmental factors. *The Journal of Comparative Neurology*, vol. 327; 97-111.

Jastreboff, P. J. (1990) Phantom auditory perception (tinnitus). Mechanisms of generation and perception. *Neuroscience*, vol. 18; 221-254.

Johansson, B. B. (2000) Brain plasticity and stroke rehabilitation: the Willis lecture. *Stroke,* vol. 31; 223-230.

Johnston, R. A. and Braisby, N. (2000) Introduction. In G. Cohen, R. A. Johnston and K. Plunkett (Eds) *Exploring cognition: damaged brains and neural networks*. Psychology Press. Hove.

Johnson-Frey. S. H. (2004) Stimulation through simulation? Motor imagery and functional reorganization in hemiplegic stroke patients. *Brain and Cognition, vol.* 55; 328-331.

Kalla, T., Downes, J. J., and van den Broek, M. (2001) The pre-exposure technique: enhancing the effects of errorless learning in the acquisition of face-name associations. *Neuropsychological Rehabilitation,* vol. 11(1); 1-16.

Kalra, L. (1994) Does age affect benefits of stroke unit rehabilitation? *Stroke,* vol.25; 346-351.

Karni, A., Meyer, G., Jezzard, P., Adams, M. M., Turner, R., and Ungerleider, G. (1995) Functional MRI evidence for adult motor cortex plasticity during motor skill learning. *Nature*, vol. 377; 155-158.

Kasten, E. and Sabel, B. A. (1995) Visual field enlargement after computer training in brain damaged patients with homonymous deficits: an open pilot trial. *Restorative Neurology and Neuroscience*, vol. 8; 113-127.

Katz, R. C. and Wertz, R. T. (1997) The efficacy of computer-provided reading treatment for chronic aphasic adults. *Journal of Speech, Language and Hearing Research*, vol. 40; 493-507.

Kauhanen, M. L., Korpelainen, J. T., Hiltunen, P., Brusin, E., Mononen, H., Määttä, R., Nieminen, P., Sotaniemi, K. A., and Myllylä, V. V. (1999) Poststroke depression correlates with cognitive impairment and neurological deficits. *Stroke*, vol. 30; 1875-1880.

Kay, J., Lesser, R. and Coltheart, M. (1992) *PALPA: Psycholinguistic Assessments of Language Processing in Aphasia*. Hove: Erlbaum.

Keil, K. and Kaszniak, A. W. (2002) Examining executive function in individuals with brain injury: a review. *Aphasiology*, vol. 16 (3); 305-335.

Keppel, C. C. and Crowe, S. F. (2000) Changes to body image and self-esteem following stroke in young adults. *Neuropsychological Rehabilitation,* vol. 10(1); 15-31.

Kertesz, A., Harlock, W. and Coates, R. (1979) Computer tomographic localization, lesion size and prognosis in aphasia and nonverbal impairment. *Brain and Language*, vol. 8; 34-50.

Kesler, S. R., Adams, H. F., Blasey, C. M. and Bigler, E. D. (2003) Premorbid intellectual functioning, education and brain size in traumatic brain injury: an investigation of the cognitive reserve hypothesis. *Applied Neuropsychology*, vol. 10 (3); 153-162.

Kimura, M., Robinson, R.G. and Kosier, J. T. (2000) Treatment of cognitive impairment after poststroke depression. *Stroke*, vol. 31;1482-1486.

Kinsella, G. J. and Duffy, F. D. (1979) Psychosocial adjustment in the spouses of aphasic patients. *Scandinavian Journal of Rehabilitation Medicine*, vol. 11; 129-132.

Kotila, M., Numminen, H., Waltimo, O. and Kaste, M. (1998) Depression after stroke: results of the FINNSTROKE study. *Stroke,* vol. 29; 368-372.

Krashen, S. D. (1973) Lateralization, language learning, and the critical period: some new evidence. *Language Learning*, vol. 23; 63-74.

Ladavas, E., Berti, A., Ruozzi, E., and Barboni, F. (1997) Neglect as a deficit determined by an imbalance between multiple spatial representations. *Experimental Brain Research*, vol. 116; 493-500.

Lambon-Ralph, M. A. (2004) Reconnecting cognitive neuropsychology: commentary on Harley's does cognitive neuropsychology have a future? *Cognitive Neuropsychology*, vol. 21 (1); 31-35.

Lang, C. (1989) Continuous figure recognition in dementia and unilateral cerebral damage. *Neuropsychologia*, vol. 27 (5); 619-628

Laufer, B. and Nation, P. (1999) A vocabulary-size test of controlled production ability. *Language Testing*, vol. 16 (1); 33-51.

Lazarus, (1993) Coping theory and research: past present and future. *Psychosomatic Medicine*, vol. 55; 234-247.

Le Dorze, G. and Brassard, C. (1995) A description of the consequences of aphasia on aphasic persons and their relatives and friends, based on the WHO model of chronic diseases. *Aphasiology*, vol. 9(3); 239-255.

Learn Direct job profiles accessed 7th June 2005

www.learndirect-advice.co.uk/helpwithyourcareer/jobprofiles/profiles/profile209/

Lenneberg, E. H. (1967) *Biological foundations of language*. New York. Wiley.

Lesser, R. and Algar, L. (1995) Towards combining the cognitive neuropsychological and the pragmatic in aphasia therapy. N*europsychological Rehabilitation,* vol. 5 (1/2); 67-92.

Levelt, W. J. M., Roelofs, A., and Meyer, A. S. (1999) A theory of lexical access in speech production. *Behavioural and brain sciences*, vol. 22; 1-75.

Linebaugh, C. W. (1999) Merging the models: what, why, how, and when in aphasia therapy. *Aphasiology*, vol. 13(2); 143-147.

Lotto, L. and de Groot, A. M. B. (1998) Effects of learning method and word type on acquiring vocabulary in an unfamiliar language. *Language Learning,* vol. 48(1); 31-69.

Lough, S., Kipps, C. M., Treise, C., Watson, P., Blair, J. R. and Hodges, J. R. (in press) Social reasoning, emotion and empathy in frontotemporal dementia. *Neuropsychologia*.

Luce, P. A. and Pisoni, D. B. (1998) Recognizing spoken words: the neighborhood activation model. *Ear and Hearing*, vol. 19(1); 1-36

Ludlow, C. L., Rosenberg, J., Fair, C., Buck, D., Schesselman, S. and Salazar, A. (1986) Brain lesions associated with nonfluent aphasia fifteen years following penetrating head injury. *Brain*, vol.109 (1); 55-80.

Lyons, F., Hanley, J. R. and Kay, J. (2002) Anomia for common names and geographical names with preserved retrieval of name and people: A semantic memory disorder. *Cortex*, vol. 38; 23-35.

Malcomess, K (2001) The Reason for Care. *RCSLT Bulletin,* November; 12-14.

Manly, T., Hawkins, K., Evans, J., Woldt, K. and Robertson, I.H. (2001) Rehabilitation of executive function: facilitation of effective goal management on complex tasks using periodic auditory alerts. *Neuropsychologia*, vol. 40 (3); 271-281.

Marsden, C. D. and Sheehy, M. P. (1990) Writer's cramp [Review]. *Trends in Neuroscience*, vol. 13; 148–53

Marshall, R. C., Freed, D. B., and Karow, C. M. (2001) Learning of subordinate category names by aphasic subjects: a comparison of deep and surface-level training methods. *Aphasiology*, vol. 15(6); 585-598.

Marshall, J. C., Halligan, P. W., Fink, G. R., Wade, D. T. and Frackowiak, R. S. J. (1997) The functional anatomy of a hysterical paralysis. *Cognition,* vol. 64; B1-B8.

Marshall, R. C., Neuburger, S. I., and Phillips, D. S. (1992) Effects of facilitation and cueing on labelling of 'novel' stimuli by aphasic subjects. *Aphasiology,* vol. 6(6); 567-583.

Marshall, J. C. and Phillips, D.S. (1983) Prognosis for improved verbal communication in aphasic stroke patients. *Archives of physical medicine and rehabilitation*, vol. 64; 597-600.

Marshall, J. C., Tompkins and Phillips, D. S. (1982) Improvement in treated aphasia: examination of selected prognostic factors. *Folia Phoniatrica*, vol. 34; 305-315.

Mateer, C. A. and Kerns, K. A. (2000) Capitalizing on neuroplasticity. *Brain and Cognition*, vol. 42; 1060-109.

Mattingley, J. B., Robertson, I., and Driver, J. (1998) Modulation of covert visual attention by hand movement: evidence from parietal extinction after right-hemisphere damage. *Neurocase,* vol. 4; 245-253.

McArthur, C., Frederick, A., Hartley, K., Yardley, C., Booth, S. and Armstrong, L. (2002) *Brief to Scottish parliament on aphasia*.

McCarthy, C., Lacey, R. and Malcomess, K. (2001) An audit of the application of care aims across the south west Thames region. *International Journal of Language Communication Disorders,* vol. 36 S; 505-510.

McCloskey, M. (2004) Does Harley have a point? comments on Harley's: does cognitive neuropsychology have a future? *Cognitive Neuropsychology*, 21 (1); 37-39.

McDonald, S., Togher, L., and Code, C. (1999) *Traumatic brain injury and communicaion disorders.* Psychology Press, Hove.

McNeil, M. R. and Pratt, S. R. (2001) Defining aphasia: some theoretical and clinical implications of operating from a formal definition. *Aphasiology,* vol. 15(10/11); 901-911.

McNeil, M. R., Odell, K. and Tseng, C. H. (1991) Toward the integration of resource allocation into a general theory of aphasia. *Clinical Aphasiology*, vol. 20; 21-39.

Meinzer, M., Djundja, D., Barthel, G. Elbert, T., and Rockstroh, B (2005) Long-term stability of improved language functions in chronic aphasia after constraint-induced aphasia therapy. *Stroke*, vol. 36; 1462-1466.

Meinzer, M., Elbert, T., Wienbruch, C., Djundja, D., Barthel, G. and Rockstroh, B. (2004) Intensive language training enhances brain plasticity in chronic aphasia. *BMC Biology*, vol. 2: 20

Merzenich, M., Jenkins, W. M., Johnston, P., Schreiner, C., Miller, S. L., and Tallal, P. (1996) Temporal processing deficits of language-learning impaired children ameliorated by training. *Science,* vol. 271; 77-81.

Mesulam (1998) From sensation to cognition. *Brain*, vol. 121; 1013-1052.

Miceli, G., Capasso, R., Daniele, A., Esposito, T., Magarelli, M. and Tomaiuolo, G. (2000) Selective deficit for people's names following left temporal damage: an impairment of domain-specific conceptual knowledge. *Cognitive Neuropsychology*, vol. 17 (6); 489-516.

Michallet, B., Tétreault, S. and Le Dorze, G. (2003) The consequences of severe aphasia on the spouses of aphasic people: a description of the adaptation process. *Aphasiology,* vol. 17 (9); 835-859.

Morgan, K., Kadom, N., Sawaki, L., Tessitore, A., Ohayon, J., McFarland, H., Frank, J., Martin, R. and Cohen, L. G. (2004) Training-dependent plasticity in patients with multiple sclerosis. *Brain,* vol. 127; 2506-2517.

Muntner, P., Garrett, E., Klag, M. J., and Coresh, J. (2002) Trends in stroke prevalence between 1973 and 1991 in the US population 25 to 74 years of age. *Stroke*, vol. 33; 1209-1213.

Murray, L. L. (2004) Cognitive treatments for aphasia: should we and can we help attention and working memory problems? *Journal of Medical Speech-Language Pathology*, vol. 12 (3); xxv-xi

Murray, L. L. (1999) Attention and aphasia: theory, research and clinical implications. *Aphasiology*, vol. 13(2); 91-111.

Mykletun, A., Stordal, E., and Dahl, A. (2001) Hospital anxiety and depression (HAD) scale: factor structure, item analyses and internal consistency in a large population. *British Journal of Psychiatry*, vol. 179; 540-544.

Nakayama, H., Jørgensen, H. S., Raaschou, H. O. and Olsen, T. S. (1994) The influence of age on stroke outcome: the Copenhagen stroke study. *Stroke*, vol. 25; 808-813.

Naeser, A. M., Helm-Estabrooks, N., Haas, G., Auerbach, S. and Sprinivasan, M. (1987) Relationship between lesion extent on Wernicke's area on computer tomographic scan and predicting recovery of comprehension in Wernicke's aphasia. *Archives of Neurology*, vol. 44; 73-82.

Nation, I. S. P. (1990) *Teaching and learning vocabulary*. Heinle and Heinle, Boston, MA.

Nation, I. S. P. (1983) Teaching and learning vocabulary. *Guidelines*, vol. 5; 12-25.

NHS Scotland (2002) *Adding life to years: report of the expert group on healthcare of older people.* National Health Service. Scotland.

Nickels, L. (2001) Spoken word production. In *The handbook of cognitive neuropsychology,* B. Rapp, ed., Psychology Press, Hove; 291-320.

Parkin, A. J. (2001) The structure and mechanisms of memory. In *The handbook of cognitive neuropsychology,* B. Rapp, ed., Psychology Press, Hove; 399-422.

Parr, S., Byng, S., Gilpin, S., and Ireland, C. (1997) *Talking about aphasia: living with loss of language after stroke*. OUP, Buckingham.

Pascual-Leone, A., Dang, N., Cohen, L. G., Brasil-neto, J. P., Cammarota, A., and Hallett, M. (1995) Modulation of muscle response evoked by transcranial magneic stimulation during the acquisition of new fine motor skills. *Journal of Neurophysiology,* vol. 74; 1037-1045.

Pascual-Leone, A. and Torres, F. (1993) Plasticity of the sensorimotor cortex representation of the reading finger in braille readers. *Brain*, vol. 116; 39-52.

Patel, M., Coshall, C., Rudd, A. G., and Wolfe, C. D. A. (2003) Natural history of cognitive impairment after stroke and factors associated with its recovery *Clinical Rehabilitation*, vol. 17; 158-166.

Pedersen, P. M., Vinter, K. and Olsen T. S. (2004) Aphasia after stroke: type, severity and prognosis. *Cerebrovascular Diseases,* vol. 17 (1); 35-43.

Pedersen, P. M., Jørgensen, H. S., Nakayama, H., Raaschou, H. O., and Olsen, T. S. (1995) Aphasia in acute stroke: incidence, determinants and recovery. *Annals of Neurology*, vol. 38(4); 659-666.

Pessah-Rasmussen, H., Engström, G., Jerntorp, I., and Janzon, L. (2003) Increasing stroke incidence and decreasing case fatality, 1989-1998. *Stroke*, vol. 34; 913-918.

Petheram, B. and Enderby, P. (2001) Demographic and epidemiological analysis of patients referred to speech and language therapy at eleven centres 1987-95. *International Journal of Language and Communication Disorders*, vol. 36(4); 515-525.

Plassman, B. L., Welsh, K. A., Helms, M. B. S., Brandt, J., Page, W. F. and Breitner, J. C. S. (1995) Intelligence and education as predictors of cognitive state in late life: a 50-year follow-up. *Neurology*, vol. 45 (8); 1446-1450

Poeck, K. Huber, W. Willmes, K. (1989) Outcome of intensive language treatment in aphasia. *Journal of Speech and Hearing Disorders,* vol. 54;471-479.

Pulvermüller, F., Neininger, B., Elbert, T., Mohr, B., Rockstroh, B., Koebbel, P., and Taub, E. (2001) Constraint-induced therapy of chronic aphasia after stroke. *Stroke*, vol. 32; 1621-1626.

Purdy, M. (2002) Executive function ability in persons with aphasia. *Aphasiology*, vol. 16(4/5/6); 549-557.

Quartarone, A., Bagnato, S., Rizzo, V., Siebner, H. R., Dattola, V., Scalfari, A., Morgante, F., Battaglia, F., Romano, M. and Girlanda, P. (2003) Abnormal associative plasticity of the human motor cortex in writer's cramp. *Brain*, vol. 126; 2586-2596.

Ramachandran, V. S. and Hirstein, W. (1998) The perception of phantom limbs: the D.O. Hebb lecture. *Brain*, vol. 121; 1603-1630.

Ramsburger, G. 2000, Preface. *Seminars in Speech and Language*, vol. 21(2); 93.

Robertson, I. H. (1999) *Mind sculpture: unleashing your brain's potential*. Bantam Press, London.

Robertson, I. H. and Murre, J. M. J. (1999) Rehabilitation of brain damage: brain plasticity and principles of guided recovery. *Psychological Bulletin*, vol. 125(5); 544-575.

Robertson, I. H. and North, N. (1994) One hand is better than two: motor extinction of left hand advantage in unilateral neglect *Neuropsychologia*, vol. 32; 1-11.

Robertson, I. H. and North, N. (1993) Active and passive activation of left limbs: influence on visual and sensory neglect. *Neuropsychologia*, vol. 31; 293-300.

Robertson, I. H. and North, N. (1992) Spatio-motor cueing in unilateral neglect: the role of hemispace, hand and motor activation. *Neuropsychologia*, vol. 30; 553-563.

Robertson, I. H. North, N., and Geggie, C. (1992) Spatio-motor cueing in unilateral neglect: three single case studies of its therapeutic effectiveness. *Journal of Neurology, Neurosurgery and Psychiatry*, vol. 55; 799-805.

Robey, R. R. (1998) A meta-analysis of clinical outcomes in the treatment to aphasia. *Journal of Speech Language and Hearing Research*, vol. 41; 172-187.

Robey, R. R. (1994) The efficacy of treatment for aphasic persons: a meta-analysis. *Brain and Language*, vol. 47; 582-608.

Robinson, R. G. (2003) Poststroke depression: prevalence, diagnosis, treatment, and disease progression. *Biological Psychiatry*, vol.54;376-387.

Robson, J., Marshall, J., Pring, T. Montagu, A. and Chiat, S. (2004) Processing proper nouns in aphasia: evidence from assessment and therapy. *Aphasiology,* vol. 18 (10); 917-935.

Rochon, E., Saffran, E. M., Berndt, R. S., and Schwartz, M. (2000) Quantitative analysis of aphasic sentence production: further development and new data. *Brain and Language*, vol. 72; 193-218.

Ross, K. B. and Wertz, R. T. (2003) Quality of life with and without aphasia. *Aphasiology*, vol. 17(4); 355-364.

Saffran, E. M., Berndt, R. S., and Schwartz, M. (1989) The quantitative analysis of agrammatic production: procedure and data. *Brain and Language*, vol. 37; 440-479.

Salmon, D. and Hodges, R. (2005) Mild cognitive impairment – cognitive, behavioral, and biological factors. *Neurocase*, vol. 11 (1); 1-2.

Sarno, M. T. (1997) Quality of life in aphasia in the first post-stroke year. *Aphasiology*, vol. 11(7); 665-679.

Sarno, M. T. (1993) Aphasia rehabilitation: psychosocial and ethical considerations. *Aphasiology*, vol. 7(4); 321-334.

Schaechter, J. D., Kraft, E., Hilliard, T. S., Dijkhuizen, R. M., Benner, T., Finklestein, S. P., Rosen, B. R., and Cramer, S. C. (2002) Motor recovery and cortical reorganization after constraint-induced movement therapy in stroke patients: a preliminary study. *Neurorehabilitation and Neural Repair*, vol. 16(4); 326-338.

Schaie, K. W. (1994) The course of adult intellectual development. *American Psychologist*, vol. 49 (4); 304-313.

Scheibel, A., Conrad, T., Perdue, S., Tomiyasu, U., and Wechsler, A. (1990) A quantitative study of dendrite complexity in selected areas of the human cerebral cortex. *Brain and Cognition*, vol. 12; 85-101.

Schmidt, N., Buchanan, L. and Semenza, C. (2004) Sparing of proper nouns and dates in aphasia. *Brain and Language*, vol. 91; 9-10.

Schmidt, N. (1998) Tracking the incremental acquisition of second language vocabulary: a longitudinal study. *Language Learning*, vol. 48(2); 281-317.

Schuell, Jenkins and Jiminez-Pabon (1964) *Aphasia in adults*. New York: Harper and Row.

Scottish Intercollegiate Guidelines Network (SIGN) (2002) Specific management and prevention strategies. In *Management of patients with stroke: rehabilitation, prevention and management of complications, and discharge planning*, vol. 64. November; 10-21.

Seitz, R. J., Azari, N. P., Knorr, U., Binkofski, F., Herzog, H., and Freund, H.-J. (1999) The role of diaschisis in stroke recovery. *Stroke*, vol. 30; 1844-1850.

Sherman, R. A., Sherman, C. J., and Parker, L. (1984) Chronic phantom and stump pain among American veterans: results of a survey. *Pain*, vol. 18; 83-95.

Shewan, C. M. and Kertesz, A. (1984) Effects of speech and language treatment on recovery from aphasia. *Brain and Language*, vol. 23; 272-299.

Shimoda, K. and Robinson, R. G. (1998) Effect of anxiety disorder on impairment and recovery from stroke. *The Journal of Neuropsychiatry and Clinical Neurosciences*, vol. 10; 34-40.

Silveri, M. C. and Gainotti, G. (1988) Interaction between vision and language in category-specific impairment. *Cognitive Neuropsychology*, vol. 5; 677-709.

Skeel, R. L. and Edwards, S. (2001) The assessment and rehabilitation of memory impairments. In Johnstone, B. and Stonnington, H. H. (Eds) *Rehabilitation of neuropsychological disorders*. Psychology Press, Hove.

Smith (1971) Objective indices of severity of chronic aphasia in stroke patients. *Journal of Speech and Hearing Disorders*, vol. 36; 167-207.

Snodgrass, J. G. and Vanderwart, M. (1980) A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory,* vol. 6(2); 174-215.

Spalletta, G., Guida, G., De Angelis, D. and Caltagirone, C. (2002) Predictors of cognitive level and depression severity are different in patients with left and right hemispheric stroke within the first year of illness. *Journal of Neurology*, vol. 249;1541-1551.

SPSS for Windows (2003) *Statistical Package for the Social Sciences 12.0*. Chicago, IL, USA.

Staff, R.T., Murray, A. D., Deary, I. J. and Whalley, L. J. (2004) What provides cerebral reserve? *Brain,* vol. 127; 1191-1199.

Starkstein, S. E., Fedoroff, J. P., Price, T. R., Leiguarda, R., and Robinson, R. G. (1993) Apathy following cerebrovascular lesions. *Stroke*, vol. 24; 1625-1630.

Starr, J. M., Nicolson, C., Anderson, K., Dennis, M. S. and Deary, I J. (2000) Correlates of informant-rated cognitive decline after stroke. *Cerebrovascular Diseases*, vol. 10 (3); 214-220.

Stephan, K. M., Fink, G. R., Passingham, R. E., Silbersweig, D., Ceballos-Baumann, A. O., Frith, C. D., and Frackawiak, R. S. J. (1995) Functional anatomy of the mental representation of upper extremity movements in healthy subjects. *Journal of Neurophysiology*, vol. 73; 373-386.

Stern, Y. (2003) The concept of cognitive reserve: a catalyst for research. *Journal of Clinical and Experimental Neuropsychology*, vol. 25; 589-593.

Stiles, J. (2000) Neural plasticity and cognitive development. *Developmental Neuropsychology*, vol. 18(2); 237-272.

Stone, V. E. (1999) The role of frontal lobes and the amygdala in theory of mind. In S. Baron-Cohen, D. Cohen and H. Tager-Flusberg (Eds), *Understanding other minds: perspectives from autism and developmental cognitive neuroscience*. Oxford University Press, Oxford.

Swales, M. and Johnson, R. (1992) Patients with semantic memory loss: can they relearn lost concepts? *Neuropsychological Rehabilitation*, vol. 2(4); 295-305.

Tallal, P., Miller, S. L., Bedi, G., Byma, G., Wang, X. Q., Nagarajan, S. S., Schreiner, C., Jenkins, W. M., and Merzenich, M. (1996) Language comprehension in language-learning impaired children improved with acoustically modified speech. *Science*, vol. 271; 81-84.

Taub, E. and Wolf, S. L. (1997) Constraint induced movement techniques to facilitate upper extremity use in stroke patients. *Topics in Stroke Rehabilitation*, vol. 3; 38-61.

Taub, E., Miller, N. E., Novak, T. A., Cook, E. W., Fleming, W. C., Nepomuceno, C. S., Connell, J. S., and Crago, J. E. (1993) Technique to improve chronic motor deficit after stroke. *Archives of Physical Medicine and Rehabilitation*, vol. 74; 347-354.

Thomas, M. and Karmiloff-Smith, A. (2002) Are developmental disorders like cases of adult brain injury? Implications from connectionist modelling. *Behavioral and Brain Sciences*, vol. 25 (6); 1-61

Tompkins, C. A., Jackson, St. T. and Schulz, R. (1990) On prognostic research in adult neurogenic disorders. *Journal of Speech and Hearing Research*, vol.33; 398-401.

Tyler, K., Russell, R., Fadili, J. and Moss, H. (2001) The neural representation of nouns and verbs: PET studies. *Brain*, vol. 124; 1619-1634.

Vakil, E., Hoffman, Y., and Myzliek, D. (1998) Active versus passive procedural learning in older and younger adults. *Neuropsychological Rehabilitation*, vol. 8(1); 31-41.

Van der Linden, M., Cornil, V., Meulemans**,** T., Ivanoiu, A., Salmon, E. and Coyette, F. (2001) Acquisition of a novel vocabulary in an amnesic patient. *Neurocase*, vol., 7 (4); 283-293.

van Hell, J. G. and Mahn, A. C. (1997) Keyword mnemonics versus rote rehearsal: learning concrete and abstract foreign words by experienced and inexperienced learners. *Language Learning*, vol. 47 (3); 507-546.

Van Mourik, M., Verschaeve, M., Boon, P, Paquier, P. and Van Harskamp, F. (1992) Cognition in global aphasia. *Aphasiology*, vol. 6; 491-499.

Vuilleumier, P., Chicherio, C., Assal, F., Schwartz, S., Slosman, D., and Landis, T. (2001) Functional neuroanatomical correlates of hysterical sensorimotor loss. *Brain*, vol. 124;1077-1090.

Warburton, E., Wise, R. J., Price, C. J., Weiller, C., Hadar, H. and Ramsay, S. (1996) Noun and verb retrieval by normal subjects. Studies with PET scans. *Brain*, vol. 119; 159-179.

Warrington, E. K. and Shallice (1984) Category specific semantic impairments. *Brain*, vol. 107;829-854.

Warrington, E. K. and McCarthy (1983) Categories of knowledge: further fracionations and an attempted integration. *Brain*, vol. 110; 1273-1296.

Ween, J. E., Verfaellie, M. and Alexander, M. P. (1996) Verbal memory function in mild aphasia. *Neurology*, vol. 47 (3); 795-801.

Weiller, C., Isensee, C., Rijntjes, M., Huber, W., Muller, S., Bier, D., Dutschka, K., Woods, R. P., Noth, J., and Diener, H. C. (1995) Recovery from wernicke's aphasia: a positron emission tomographic study. *Annals of Neurology*, vol. 37(6); 723-732.

Weisenburg, T. H. and McBride, K. E. (1935) *Aphasia: a clinical and psychological study*. New York: The Commonwealth Fund.

Whalley, L. J., Deary, I. J., Appleton, C. L. and Starr, J. M. (2004) Cognitive reserve and the neurobiology of cognitive aging. *Ageing Research Reviews*, vol. 3 (4); 369-382.

Wilson, B. and Hughes, E. (1997) Coping with amnesia: the natural history of a compensatory memory system. *Neuropsychological Rehabilitation*, vol. 7 (1); 43-56.

Wilson, B. and Patterson, K. (1990) Rehabilitation for cognitive impairment. Does cognitive psychology apply? *Applied Cognitive Psychology*, vol. 4; 247-260.

World Health Organisation (1996) What quality of life? World Health Organization Quality of Life Assessment. *World Health Forum*, vol. 17(4); 354-356.

Yang, T. T., Gallen, C., Ramachandran, V.S., Cobb, S., Schwartz, B. J., and Bloom, F. E. (1994) Noninvasive detection of cerebral plasticity in adult human somatosensory cortex. *NeuroReport*, vol. 5; 701-704.

Yasuda, K., Nakamura, T., and Beckman, B. (2000) Brain processing of proper names. *Aphasiology*, vol. 14(11); 1067-1089.

Zigmond, A. S. and Snaith, R. P. (1983) The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica*, vol. 67; 361-370.

Appendix 2.1

Main representative processes accessed according to the Cognitive Neuropsychology model (Kay et al, 1992; Ellis and Young, 1996)

Module and function	Tasks used for assessing the integrity of module/ pathway
Auditory Phonological Analyses Processes incoming acoustic information, possibly into phonemes or segments	Non-word minimal pair judgement on a same/ different basis (listening)
Phonological Input Lexicon Contains representations of every word in a person's vocabulary recognising when a spoken word is known	Lexical decision on a real/ non-word basis (listening)
Phonological Output Lexicon Stores abstract specification for the spoken form of every word in person's vocabulary	Picture Syllable test where pictures are sorted on the basis of syllable structure (listening or image)
Acoustic to Phonological Conversion Represents the ability to repeat heard non-words	Repetition of non-words (listening)
Phonological Output Buffer Acts as a brief temporary storage of sounds to be assembled for a spoken word	Repetition of increasing length of strings of letters (listening)
Visual/ Object Recognition Processes incoming picture/ object material	Pictures presented on a real or made up basis
Semantic System Stores the knowledge of the meaning of all known words	Synonym judgement on same / different basis, categorisation tasks (listening, reading or images)
Abstract Letter Identification Processes incoming written information and is basically a letter identification process	Cross case letter matching on a same/ different basis (reading)
Orthographic Input Lexicon Contains representations of every word in a person's vocabulary recognising when a written word is known	Lexical decision on a real/ non-word basis (reading)
Orthographic Output Lexicon Stores abstract specification for the written forms of all words in a person's vocabulary	Written syllable matching (reading)
Letter to Phonological Conversion Represents the ability to read aloud non-words	Read aloud non-words (reading)
Phonological to Letter Conversion Represents the ability to spell written non-words	Written spelling of non-words (writing)
Copy Words Represents the ability to copy written letters or words	Copy written words (writing)
Graphemic Output Buffer Acts as a brief temporary storage of string of letters in correct order when writing words	Written spelling of increasing length of words (writing)

Appendix 3.1

Preliminary study one: Novel stimuli

Number	Creature name	Special skill	Eye colour
1	FUTARG	FREEZES ITS ENEMIES	BLUE
2	VINTROK	FILTERS BAD VIBES	RED
3	SARTLE	SHOOTS FIREBALLS	ORANGE
4	ZOODOP	FORECASTS THE WEATHER	BLUE
5	YAMTORK	EMITS SOUND WAVES	GREEN
6	HAMEKIN	CREATES CALM	ORANGE
7	LUNDRIL	DEADLY LASER BEAMS	YELLOW
8	CURVOL	PSYCHIC	GREEN
9	WANGOR	SPINS NETS	RED
10	SNAITLE	POISONOUS SPIKES	YELLOW

Appendix 3.2

Preliminary study one: Training procedure script

RED ALERT! RED ALERT! RED ALERT! PLANET EARTH HAS BEEN INVADED….I REPEAT… PLANET EARTH HAS BEEN INVADED

So far the aliens have:

1. cut off the water supply,
2. banned cable t.v.,
3. played boy-band music every day!

You are part of *OPERATION ZOG*
There are 10 aliens that we know of. The evil ones must be stopped. The noble aliens befriended.
You will only have ONE chance. You MUST succeed!

Knowledge is the weapon that will save our planet

Do you recognise any of these aliens? *[Show participants each alien image]*
Your orders are to memorise the (i) name, (ii) eye colour and (iii) skill of each alien

Your commander MUST have this information in 20 minutes or the earth will be destroyed.

The survival of the planet depends on you……GOOD LUCK!

HERE ARE THE TEN ALIEN PROFILES……..
[Researcher presents each alien in turn]

1. The first alien is **FUTARG** and it **FREEZES** ITS ENEMIES with its cold **BLUE** eyes
2. Here is **VINTROK**. Its **RED** eyes look scary but its skill is to **FILTER BAD VIBES**.
3. Here is **SARTLE**. its eyes are **ORANGE.** Don't let its friendly face fool you it **SHOOTS FIREBALLS.**
4. This alien is called **ZOODOP**. It has **BLUE** eyes and can **FORECAST THE WEATHER.**
5. **YAMTORK** has **GREEN** eyes. Its skill is to **EMIT SOUND WAVES**. We don't know yet if it's a danger.
6. This is **HAMEKIN**. It has **ORANGE** eyes and is skilful in **CREATING CALM**
7. Here is **LUNDRIL**. Its **YELLOW** eyes can **EMIT DEADLY LAZER BEAMS**
8. This is **CURVOL**. It has **GREEN** eyes and it has **PSYCHIC** skills.
9. **WANGOR** has **RED** eyes and can **SPIN NETS.**
10. The last alien **SNAITLE** has **YELLOW** eyes. Beware it has very **POISONOUS SPIKES.**

Appendix 3.2 (continued)

Preliminary study one: Training procedure script

Lets go through those again. Look at the pictures carefully and memorize them. Remember we are counting on you!!

1.	**FUTARG**	**BLUE EYES**	**FREEZES ITS ENEMIES**
2.	**VINTROK**	**RED EYES**	**FILTERS BAD VIBES**
3.	**SARTLE**	**ORANGE EYES**	**SHOOTS FIREBALLS**
4.	**ZOODOP**	**BLUE EYES**	**FORECASTS THE WEATHER**
5.	**YAMTORK**	**GREEN EYES**	**EMITS SOUND WAVES**
6.	**HAMEKIN**	**ORANGE EYES**	**CREATES CALM**
7.	**LUNDRIL**	**YELLOW EYES**	**DEADLY LASER BEAMS**
8.	**CURVOL**	**GREEN EYES**	**PSYCHIC**
9.	**WANGOR**	**RED EYES**	**SPINS NETS**
10.	**SNAITLE**	**YELLOW EYES**	**POISONOUS SPIKES**

<u>Now take 5 minutes to LEARN these details before sending them to your commander.</u>

[Researcher leaves the participant alone in room with alien details and pen and paper]

[Researcher returns to room after five minutes has elapsed and continues playing the recorded message]

Your time is up!
Your commander has made contact
Your orders are as follows…

1. Tell your commander everything that you can remember about the aliens *[responses recorded]*
2. You will now be given a picture of each alien:
   a. Fill in the alien's name
   b. Fill in the alien's skill
   c. Colour in the alien's eyes with the correct colour

[this is not timed – when participant indicates that they are finished – play tape]

WELL DONE! YOU HAVE DONE YOUR PLANET PROUD………

Appendix 3.3

Preliminary study one: Qualitative data responses for the procedural questions

Questions	Responses	Number of participants
What were main pressures?	Time Wanting to succeed Unfamiliarity of names Just having to remember	10 4 2 1
Did auditory information help when learning the words?	Yes No Prefer written medium No idea No difference Good guide of pronunciation As many cues / clues as possible is important	5 2 1 1 1 1 1
How did the context help your learning? i.e. saving planet scenario	It was fun Excellent scenario, motivates Would like more special effects! Just a joke Was a distraction Didn't need as motivation No difference to learning Unnecessary background information	1 1 1 1 2 2 2 2
Did you find the instructions clear and easy to follow?	Yes	10
How did listening to a tape rather than face-to-face affect your learning?	Tape was fine / better Face-to-face better as can ask questions Don't know / no preference	5 2 3
Was the time long enough? If not, how much extra time would be needed?	Not enough time and most people were unsure as to how much extra time. Some suggested an extra 10-15 minutes	10

Appendix 3.4a

Preliminary study two: Stimuli used for Group B

Number	Creature name	Special skill	Eye colour
1	JUNFLIZ	CREATES STORMS	BLUE
2	SHORPINE	CREATES HARMONY	RED
3	MAYTOR	SPEAKS ALL LANGUAGES	ORANGE
4	TRAIGOL	TELEPATHIC	BLUE
5	DREEPLE	MUTATES	GREEN
6	POPKINEL	EMITS PERFUME	ORANGE
7	FEETOKEL	DREAM CHARMER	YELLOW
8	PENTAR	CREATES INVISIBLE CLOAK	GREEN
9	SILVARK	X-RAY VISION	RED
10	PONCHINO	HYPNOTISES	YELLOW

Appendix 3.4b

Preliminary study two: Stimuli used for Group A

Number	Creature name	Special skill	Eye colour
1	PONCHINO	CREATES HARMONY	BLUE
2	JUNFLIZ	EMITS PERFUME	RED
3	TRAIGOL	CREATES STORMS	GREEN
4	SHORPINE	MUTATES	BLUE
5	PENTAR	HYPNOTISES	YELLOW
6	FEETOKEL	TELEPATHIC	YELLOW
7	POPKINEL	SPEAKS ALL LANGUAGES	RED
8	SILVARK	CREATES AN INVISIBLE CLOAK	ORANGE
9	DREEPLE	DREAM CHARMER	ORANGE
10	MAYTOR	X-RAY VISION	GREEN

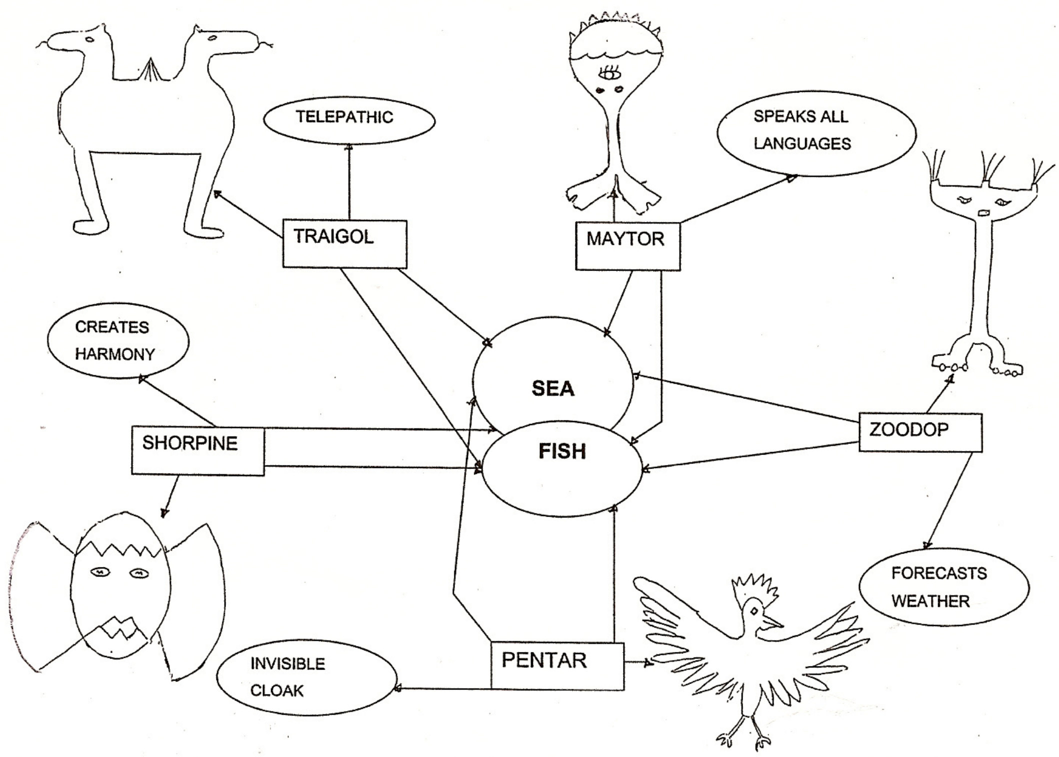
Appendix 3.5

Preliminary study two: Qualitative data responses for the procedural questions

Questions	Responses	Number of participants
Did learning strategies discussion help you learn the various items?	Yes / Most definitely To an extent Only some not all No / not really	5 1 1 1
What strategies did you use to try to memorise these items?	Mnemonic Word similarity Shapes Sound symbolism Associations with objects and people Tried to remember first letter of every name Connecting skills and names to pictures	3 3 3 1 2 2 3
What do you think may have hindered your learning?	Rushed for personal work Short time to memorise Spent too much time trying to come up with mnemonics Short term memory limitations Not my first language More pressure to do better	1 2 1 1 1 1
Do you think that the time was long enough to learn these representations?	No Yes	9 1
If not, how much more time do you think you would have needed?	1minute 2 minutes 5 minutes 10 minutes At least another 15 minutes 3 times the amount given	1 2 3 1 1 1

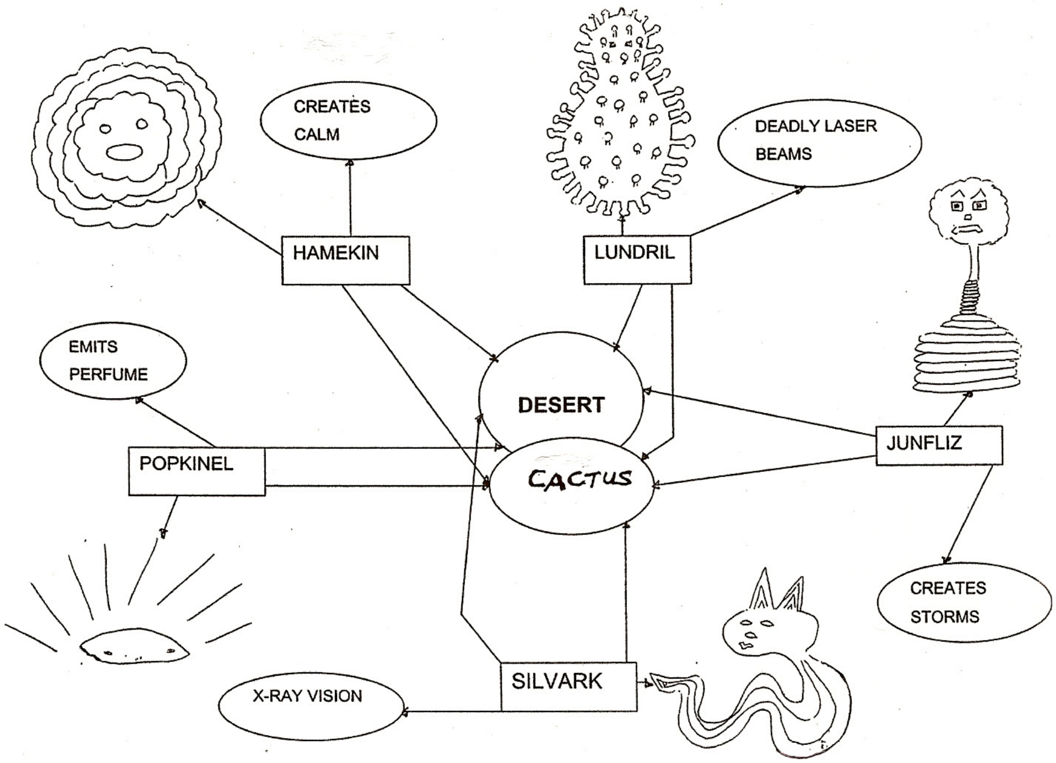
Appendix 3.6

Stimuli used for the main investigation (creature images with names, skills and linked to their food and habitat)



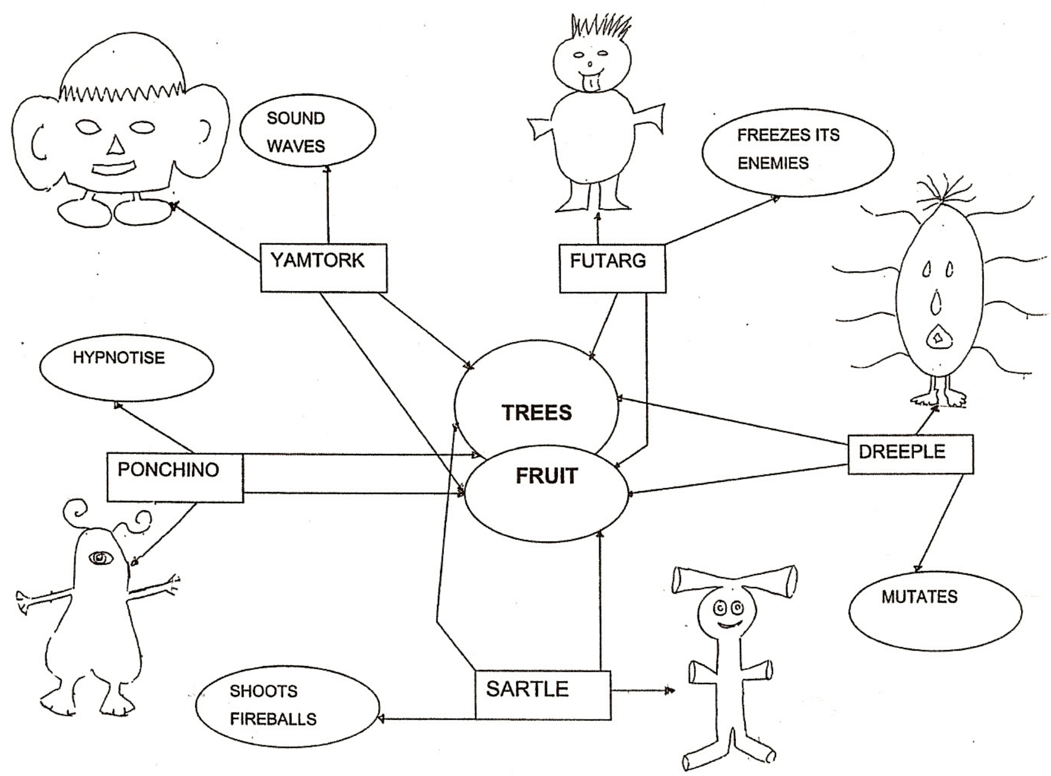
Appendix 3.6 (continued)

Stimuli used for the main investigation
(creature images with names, skills and linked to their food and habitat)



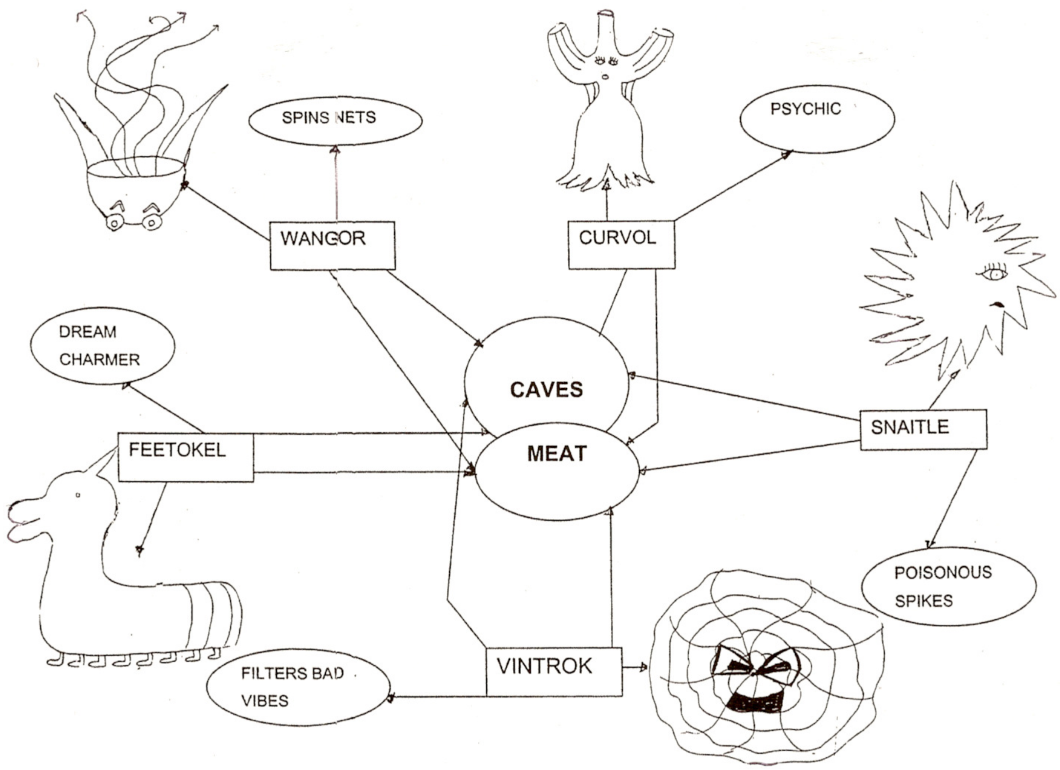
Appendix 3.6 (continued)

Stimuli used for the main investigation
(creature images with names, skills and linked to their food and habitat)



Appendix 3.6 (continued)

Stimuli used for the main investigation (creature images with names, skills and linked to their food and habitat)



Appendix 4.1

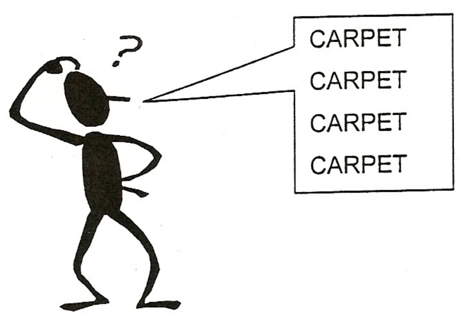
Methods of learning new information
Sheet given to and discussed with all participants

Page 1/2

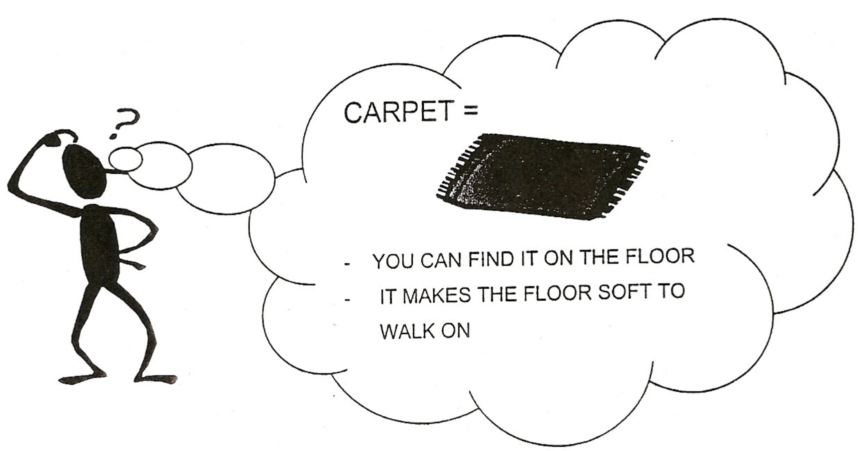
WAYS OF LEARNING NEW INFORMATION

IF YOU DIDN'T KNOW WHAT THE WORD CARPET WAS YOU COULD LEARN IT BY.....

Repeating the word again and again.........



Visualising the word and its meaning.........

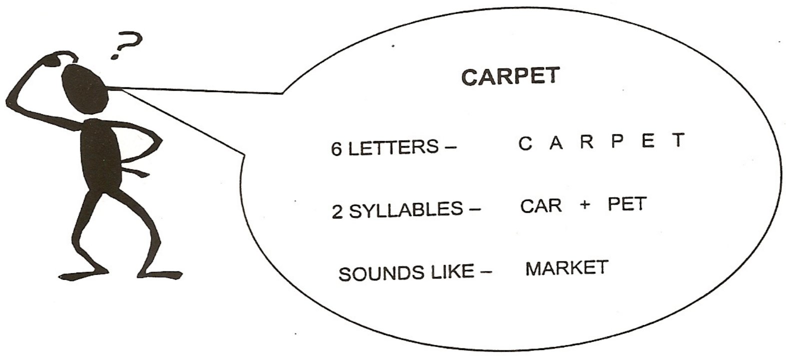


Appendix 4.1 (continued)

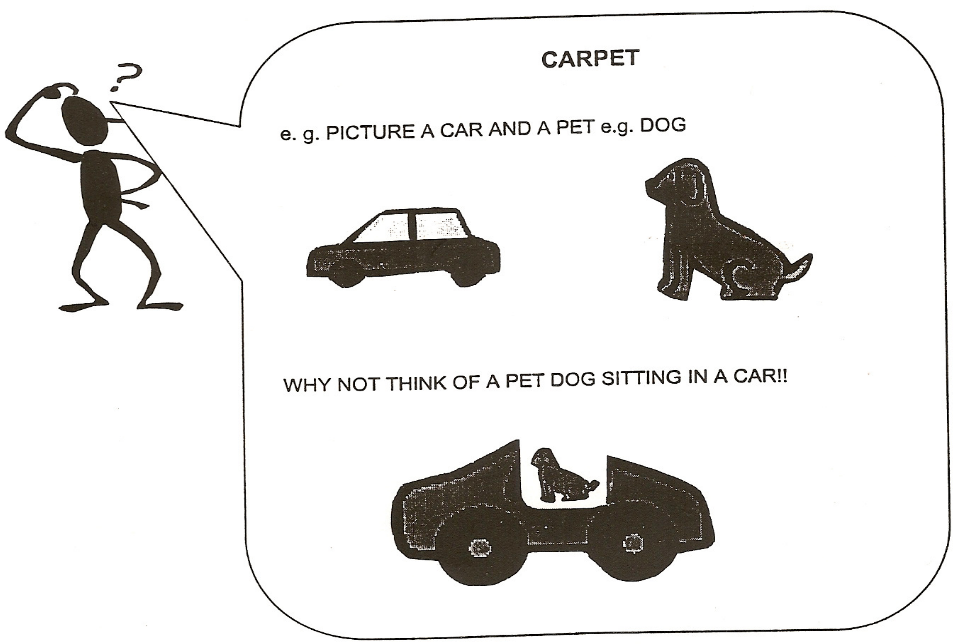
Methods of learning new information
Sheet given to and discussed with all participants

Page 2/2

Describing the way the word is made up............



Using your imagination.....



Appendix 4.2

Hospital Anxiety and Depression Scale (HADs) (Zigmond and Snaith, 1983)

Patients are asked to choose one response from the four given for each statement indicating how it currently describes their feelings. The questions relating to anxiety are marked "A" and to depression "D". The score for each answer is given in the right column.

A	**I feel tense or 'wound up':**	
	Most of the time	3
	A lot of the time	2
	From time to time, occasionally	1
	Not at all	0

D	**I still enjoy the things I used to enjoy:**	
	Definitely as much	0
	Not quite so much	1
	Only a little	2
	Hardly at all	3

A	**I get a sort of frightened feeling as if something awful is about to happen:**	
	Very definitely and quite badly	3
	Yes, but not too badly	2
	A little, but it doesn't' worry me	1
	Not at all	0

D	**I can laugh and see the funny side of things:**	
	As much as I always could	0
	Not quite so much now	1
	Definitely not so much now	2
	Not at all	3

A	**Worrying thoughts go through my mind:**	
	A great deal of the time	3
	A lot of the time	2
	From time to time, but not too often	1
	Only occasionally	0

D	**I feel cheerful:**	
	Not at all	3
	Not often	2
	Sometimes	1
	Most of the time	0

Appendix 4.2 (Continued)

Hospital Anxiety and Depression Scale (HADs)

A	**I can sit at ease and feel relaxed:**	
	Definitely	0
	Usually	1
	Not often	2
	Not at all	3

D	**I feel as if I am slowed down:**	
	Nearly all the time	3
	Very often	2
	Sometimes	1
	Not at all	0

A	**I get a sort of frightened feeling like 'butterflies' in the stomach:**	
	Not at all	0
	Occasionally	1
	Quite often	2
	Very often	3

D	**I have lost interest in my appearance:**	
	Definitely	3
	I don't take as much care as I should	2
	I may not take quite as much care	1
	I take just as much care as ever	0

A	**I feel restless as I have to be on the move:**	
	Very much indeed	0
	Quite a lot	1
	Not very much	2
	Not at all	3

D	**I look forward with enjoyment to things:**	
	As much as I ever did	0
	Rather less than I used to	1
	Definitely less than I used to	2
	Hardly at all	3

A	**I get sudden feelings of panic:**	
	Very often indeed	3
	Quite often	2
	Not very often	1
	Not at all	0

Appendix 4.2 (Continued)

Hospital Anxiety and Depression Scale (HADs)

D	**I can enjoy a good book or radio or TV program:**	
	Often	0
	Sometimes	1
	Not often	2
	Very seldom	3

Scoring
Add the As = anxiety and add the Ds = depression
The norms below give an indication of Anxiety and Depression levels
0-7 = Normal
8-10 = Borderline abnormal
11-21 = Abnormal

APPENDIX 4.3

Cognitive Linguistic Quick Test – severity ratings and scores (Helm-Estebrooks, 2001)

Tasks include participants giving personal details verbally, symbol cancellation (identifying target symbols from a large range of different symbols), confrontation naming (10 items), clock drawing (completing a clock by insertion of the numbers and indicating a specified time), story retelling with six related auditory comprehension closed questions (yes/no responses), symbol trails (connection of alternate shapes of varying sizes), spoken generative naming (animals and words beginning with the letter [m]) design memory (identification of pairs of abstract designs from selection of six designs following memorisation), maze completion (completion of a simple and more complex maze) and design generation (creation of different designs using only four lines and four dots).

Severity ratings for participants in the study

Severity ratings table for ages 18-69 years				
Cognitive domain	Within normal limits	Mild	Moderate	Severe
Attention	215-180	179-125	124-50	49-0
Memory	185-155	154-141	140-110	109-0
Executive Functions	40-24	23-20	19-16	15-0
Language	37-29	28-25	24-21	20-0
Visuospatial skills	105-82	81-52	51-42	41-0
Clock drawing skills	13-12	11-10	9-8	7-0

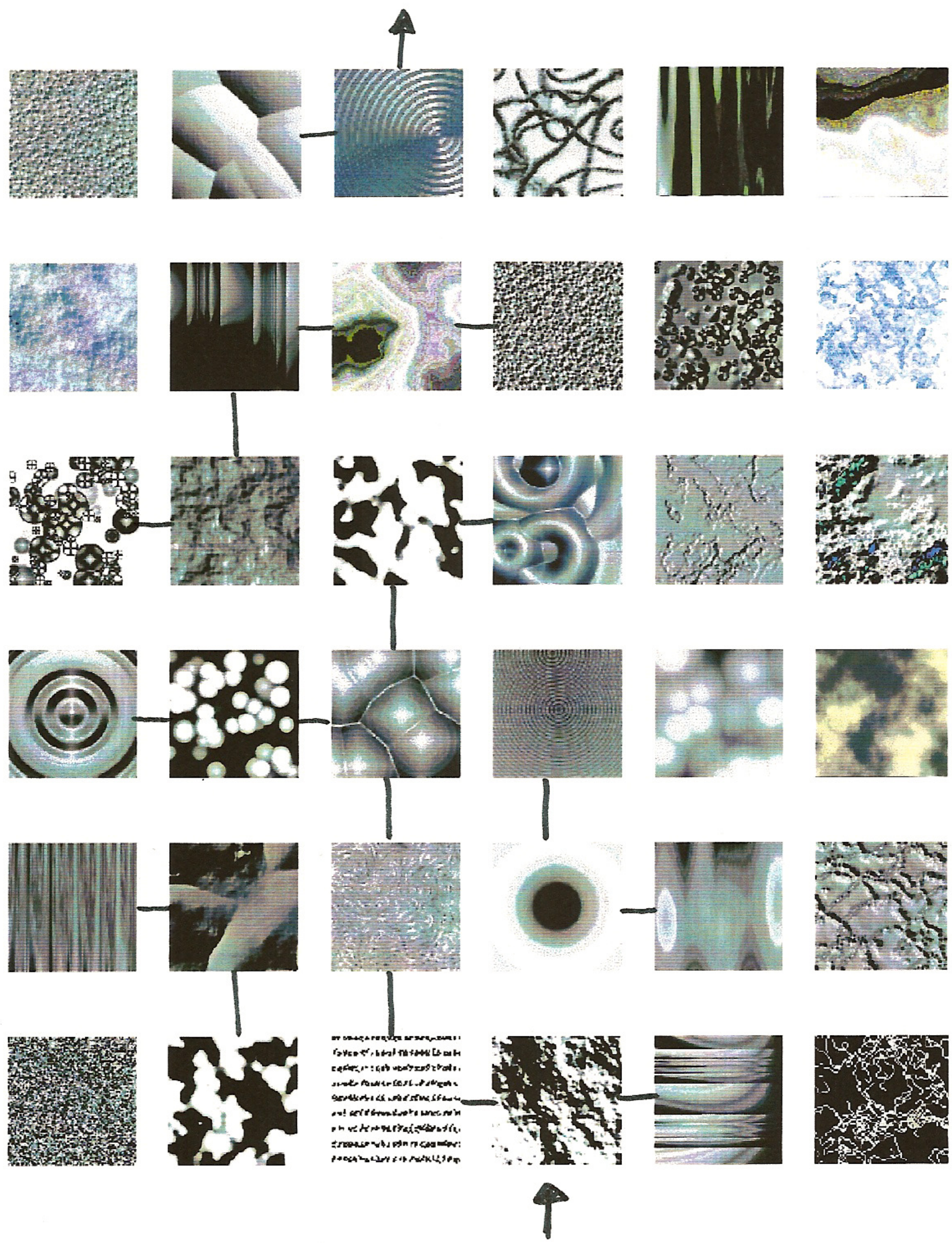
Method of obtaining scores for each cognitive domain

Tasks	WNL	Attention	Memory	Executive Functions	Language	Visuospatial skills
Personal Facts	8		x 7 =		x 1 =	
Symbol Cancellation	11	x 9 =				x 2 =
Confrontation Naming	10				x 1 =	
Story Retelling	6	x 2 =	x 6 =		x 1 =	
Symbol Trails	9	x 3 =		x 1 =		x 2 =
Generative Naming	5		x 1 =	x 1 =	x 1 =	
Design Memory	5	x 2 =	x 10 =			x 4 =
Mazes	7	x 4 =		x 1 =		x 3 =
Design Generation	6	x 1 =		x 1 =		x 1 =

Appendix 4.4

Non-linguistic learning task
Stepping stone route (adapted from Evans et al., 2000)

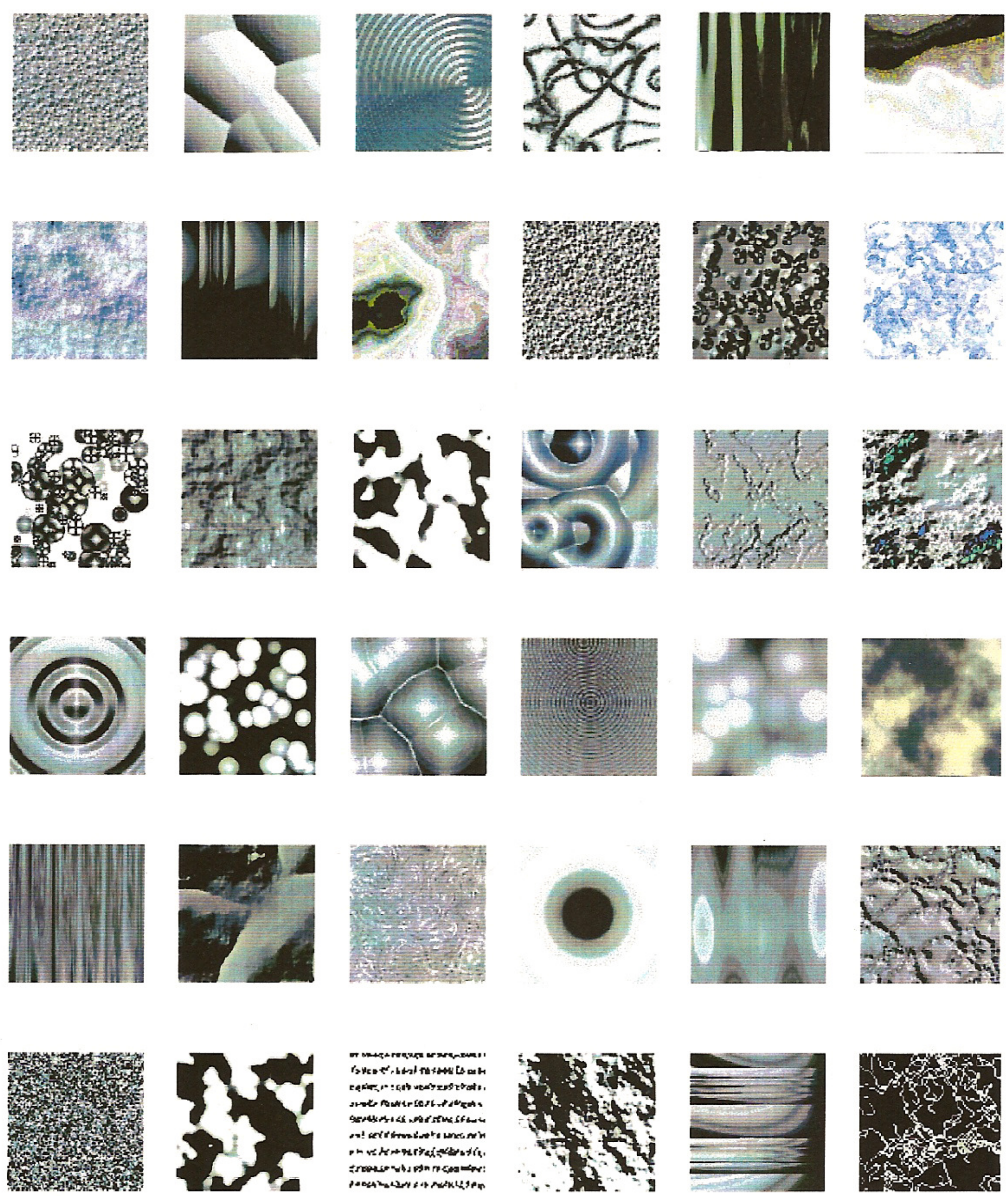
<u>Errorless learning format:</u>



Appendix 4.4 (continued)

Non-linguistic learning task
Stepping stone route (adapted from Evans et al., 2000)

<u>Immediate and delayed assessment format:</u>



Appendix 4.5

Language screening assessment

	Target	Sounds like
1	Marriage	
2	Hetal	(petal)
3	Elephant	
4	Pretch	(fetch)
5	Pill	
6	Drister	(blister)
7	Night	
8	Sping	(ring)
9	Foaster	(coaster)
10	Mercy	
11	Character	
12	Tanacco	(tobacco)
13	Binus	(bin)
14	Idea	
15	Itony	(iron)
16	Realm	

These words were used for the following tasks:

1. Word and non-word repetition task
2. Auditory lexical decision
3. Reading of words and non-words

	Picture	Semantic cue
1	**<u>P</u>**encil	Something you write with
2	**<u>Gl</u>**ass	You drink from it
3	**<u>A</u>**pple	It's a fruit
4	**<u>E</u>**nvelope	For putting a letter in
5	**<u>B</u>**anana	It's long and yellow
6	**<u>C</u>**igarette	You smoke it
7	**<u>Ch</u>**ain	Made of metal links
8	**<u>B</u>**arrel	For storing beer
9	**<u>O</u>**wl	A night bird
10	**<u>K</u>**angaroo	Has a pouch
11	**<u>Sl</u>**edge	It's for sliding in the snow
12	**<u>K</u>**ite	It flies in the wind

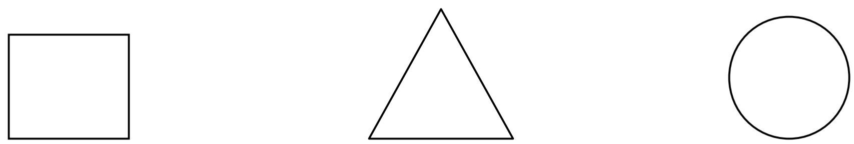
Pictures representing these words from Snodgrass and Vandervart (2001) were used for the naming test. If participants were unable to spontaneously name an item they were given a semantic cue and following that if still unsuccessful, a phonemic cue would be given (as underlined).

Appendix 4.5 (continued)

Language screening assessment

CATAGERISATION TASKS

1. **Participants were asked to divide 15 black and white shapes into three piles, one for squares, one for triangles and one for circles.**



5 SQUARES 5 TRIANGLES 5 CIRCLES

2. **Participants were asked to divide 15 pictures into three piles, one for fruit, one for vegetables and one for clothes.**

3. **They were then asked to divide written words into three piles, one for fruit, one for vegetables and one for clothes. These were the same items as the pictures above. The items were as follows:**

FRUIT	VEGETABLES	CLOTHES
Cherries	Peas	Shirt
Apple	Mushrooms	Jumper / sweater
Grapes	Cabbage	Jacket
Banana	Carrot	Gloves
Pineapple	Corn	Socks

<u>Spelling to dictation:</u>

	Target	Sounds like
1	Cat	
2	Nar	(car)
3	Holiday	
4	Troke	(cloak)
5	Smode	(rode)
6	Frog	
7	Yacht	
8	Elephant	
9	Churse	(nurse)
10	Ghost	
11	Snite	(bite)
12	Doop	(loop)

These words and non-words were used for the spelling to dictation task

Appendix 4.6

Familiar, trained and untrained non-word stimuli for each training session

	Familiar creatures	Newly learnt words	Non-words (untrained)
Session 1	DOG	FUTARG	SAMMER
	COW	SHORPINE	SUTIRE
	CAT	DREEPLE	LUTTER
	MOUSE	PENTAR	WEMBOW
	GOAT	SARTLE	MINNER
Session 2	SPIDER	MAYTOR	TRANTOR
	HEN	JUNFLIZ	SHALITY
	FISH	FEETOKEL	BARANTRE
	LION	PONCHINO	STADENT
	KITTEN	LUNDRIL	SOGMY
Session 3	WASP	VINTROK	FANNEL
	MONKEY	HAMEKIN	PISTURE
	BIRD	ZOODOP	MINACLE
	HAMSTER	SILVARK	TRENSON
	PUPPY	POPKINEL	TANACCO
Session 4	TIGER	WANGOR	PHEORY
	CAMEL	YAMTORK	BINUS
	DUCK	SNAITLE	OTION
	CRAB	CURVOL	MIRTAGE
	DONKEY	TRAIGOL	FELLY

Appendix 4.7

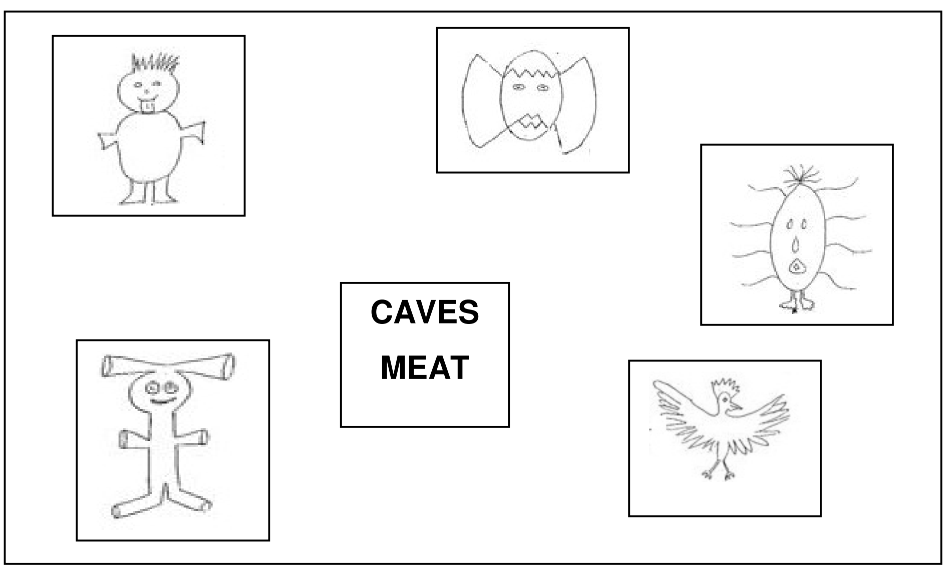
Practise assessment tasks provided during the independent learning time

Example of syllable completion task:
Participants match the beginning of the creature name [FU] with its correct final syllable [TARG] from a selection of the final syllables belonging to the creatures that were trained that session.

FU-	-TARG
	-PLE
	-PINE
	-TAR
	-TLE

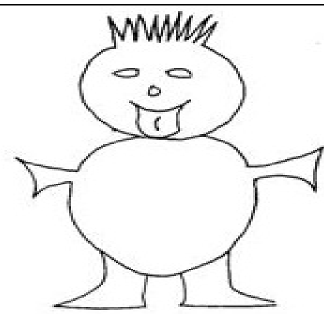
Example of a semantic matching task:

Participants practise matching food and habitat source to correct creatures:



Appendix 4.8

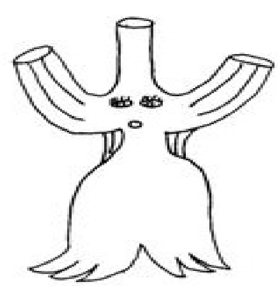
Examples of written and picture details of creatures



FUTARG

FU TARG

SKILL:	FREEZES ENEMIES
EATS:	FRUIT
LIVES NEAR:	TREES



CURVOL

CUR VOL

SKILL:	PSYCHIC
EATS:	MEAT
LIVES NEAR:	CAVES

APPENDIX 5.1

Participant Information Sheet for Main investigation

Queen Margaret University College

EDINBURGH

An investigation into whether the damaged adult linguistic system is capable of acquiring new semantic and phonological representations

(INFORMATION SHEET)

Who am I?
I am a registered speech and language therapist, currently working as a research student at Queen Margaret University College in Edinburgh.

I am interested in finding out how adults who have had a stroke or other brain injury learn new knowledge. This information will help inform speech therapists and psychologists as to how the brain heals itself and learns after injury.

What does the study involve?
If you decide to take part in the study your speech and language abilities will be assessed first.

You will then be trained in new information involving a home-study pack on a daily basis for four consecutive days. I will be with you to make sure that you don't have any difficulties with the tasks. After this training period you will be assessed on what you have learned.

The learning and assessment of this new knowledge will involve tasks such as naming pictures, matching words to pictures, reading and writing.

Where will it take place?
If it is convenient for you I will come to your home to teach and assess you during the period of the study. If this does not suit you then we will arrange a mutually suitable venue and any transport costs e.g. taxi fares will be paid for you.

Where can I find out more information?
If you require any further information either now or at any stage during the project please do not hesitate to contact my supervisor Dr. Linda Armstrong or myself (see contacts below).

Helen McGrane
Speech and Language Therapist
Phone: 0131 317 3693
Queen Margaret University College
Clerwood Terrace
Edinburgh, EH12 8TS

Dr. Linda Armstrong
Speech and Language Therapist
Phone: 01738 473714
SLT Department
Perth Royal Infirmary
Perth, PH1 1NX

APPENDIX 5.2

Participant consent form

Queen Margaret University College

EDINBURGH

An investigation into whether the damaged adult linguistic system is capable of acquiring new semantic and phonological representations

(CONSENT FORM)

1. I agree to participate in this study.
2. I have read and understood the information sheet and this consent form.
3. I have had the opportunity to ask questions about my participation.
4. I understand that I am under no obligation to take part in this study.
5. I understand that any audio or written records will be used only for research and/or teaching purposes and that I will not be identified by name.
6. I understand that I have the right to withdraw from this study at any time, for any reason.
7. I agree / do not agree to my medical records being inspected by the main researcher who is a registered speech and language therapist.
8. I agree / do not agree to my GP being informed about my participation in this study.

   Name of GP (PRINTED) ______________________________

My name (PRINTED) ______________________________________

My address (PRINTED) ____________________________________

____

My signature ____

Date ___________________

Thank you for completing this consent form.
Please return it with the questionnaire to Helen Mc Grane

Appendix 5.3

Narrations of Cinderella story by participants

(broad transcription of spoken and written formats)
(*unw* – unintelligible word ; *ilw* – illegible word) in brackets [*assessor*]

5.3a C1

Spoken narration
eh Cinderella was eh a princess but she was made to do the tʃɪtʃən the tʃɪtʃən duties and eh washing the floor and eh..em…..cleaning up and ……em doing the washing up and ….em well the ugly sisters ewre out em….she made…em…em..the fairy godmother appeared and em granted her three wishes and ……em…and…and….em…em..and…em…em..eh a ball was her final wish and em em she must em Cinderella must be out of the clock em out of the em clock by eh twelve midnight and em…em and the em…g..g..eh they had em carriages the eh little mice drew and they were transformed into humans and em when they got to the ball she danced with the prince and at midnight em she left hurriedly and em….ran out to…eh..coach…eh…em but the prince…em….em…spotted her shoes and came and looked for her and…eh…..found her and they got married.

Written narration
Cenceller was a prince~~e~~ss, but she was treated like a servant. When the ugly sisters ~~are~~ ~~was~~ere out, a Fairy Godmother appeared and granted her three wishes. She would like to go to the ball and so ~~?~~ her fairy Godmother fixed it. A pumpkin was made in to a coach, rat became ~~humans~~ payboys and she made a beauifit dress. Her Fairy Godmother be back at midnight. So she went to a ball almost forgetting to be back at midnight. She was dancing with a prince and rushed out and one of her shoes ~~??~~ get leave ~~lif~~ behind. The prince found it and came looking for her and ~~get married~~. found her. and they were married.

5.3b P3

Spoken narration
Eh eh is Cinderella and it's the good fairies, the good fairies and they are two good fairies, the one good fairy and two things against them. Yeh, and eh yeh [*yeh*], it's the, it's the, the…..and and the good fairy is the f…f..the f..I can't say it very well today. I don't know. I (*unw*) today ……[*just do your best*]. Yeh, the good fairy was in the is in the was in the …good fairy…ah I can't say it again. I can't say it this way…[*so there was Cinderella…..*] the good fairy and two bad ones *[right*] they are, the two are going to the ball, and they are going to the ball and this one is going not to the ball and then they goings to the ball with. The fe the fe the fe the fe the fe fffairy and thing was there and he was [out of breath] and he was taking the thing to the fairy and then ehee…..he wasn't …..he went to the ball with the and the good fairy and he was seven, seven, 'ah for crying out loud' [*so how did they get to the ball*] they got to the ball with the fairy the fairy godmother and and the coaches and things. And then he goes to the ball and then he comes back from the ball…..himself….goes to the ball himself….and he goes to the ball…that's right…then he goes yes to the ball. [*and what happened at the ball*]..well to the ball…and he goes to the ball for till sesesesesen midnight and he goes tp, then he goes to the ball himself, he goes and the good the good the good princess the prince and there's a goes to the ball and he comes into the ball and he finds to the ball…and dear me that is terrible….and he was to the ball and comes to…..and he finds the ball that the good fairy is a little boy or a girl [*grand*] and then he and he marries him.

Written narration (P3 crossed out some words as below)
Cindella + 2 ~~*ilw*~~ two sisters, ~~*ilw*~~ Prince Gold silver slipper ~~all *ilw* metulbic suetal *ilw*~~

Appendix 5.3 (Continued)

Narrations of Cinderella story by participants

(broad transcription of spoken and written formats)
(*unw* – unintelligible word ; *ilw* – illegible word) in brackets [*assessor*]

5.3c C3

Spoken narration

She was un ……well, she wasn't an orphan….oh aye, she was. She was an orphan. She's had a father an accident…I think it's the horse….eh…oh eh ssCinderella was a step mother had two daughters and Cinderella was the orphan and buttons helped her. She was in the kitchen and……eh….the wood eh the garden up the stick and he she eh kʌ come came across was a prince but he was inconik..incognito. ah oh..oh for gods sake…[what happened then?] eh..oh for gods sake..then..they had a ball and her ssisters sep step sisters gurrr eh she carried out ɔ: eh dresses for her sister sisters em…she was done eh sts sli..ts..oh come on…s sweeping up the floor she was dɔ: done eh…trodden eh…I'm no getting to the ball and the b eh fairy godmother eh cam an whisk no the pumpkin and eh the mice and oh don't know what the kæɹə eh the….fairy godmother wen oh wanted to eh the Cinderella was in white…oh god and the carriage pʌmpɪn and the …I don't know carrots oh sh after they went to the ball…for gods sake.. lovely eh oh beautiful dress..the oh lots of stairs ah..he…was the oh the prince prince? was enchanted by her and they danced n danced oh the….clock ssstɪ started to…no..12 o'clock "oh I must get back to the carriage"..the..oh her sisters was oh the tʃʉ was..oh whats the word…oh….left the shoe the prince caught it…eh….the Cinderella was in the coach…and…the prince's getting eh..eh..married what thed shoe the lady that lost the shoe..and the se stepsisters was "oh no, I want no". the s prince no..the..eh prince is dev devastated an..oh god.the buttons said "I'll know..i know the girl "Cinderella…oh..come..oh..se step sister "oh no, no" Cinderella cam off the shoe. Oh happily ever after.

Unable to attempt written narration as was unwell

5.3d C4

Spoken narration

There was a ball but…….eh.sɪn sɪnə wanted to go to ..but didn't have anything to go in eh so eventually eh she she went eh Lapland no…no…she she went to the ball and …… *[what happened then?]* she she left her her one of her f…one of her l l one of her shoes and the the beautiful prince picked it up and says that *[unw]* thing fitted [yes] and eh so the next day he went in and checked all [wnl and hes and and eh [unw] the house where she stayed. There was the two of her sisters and her. He's checked the two the two other ssisters first and and they of course they were trying all sorts to get it to fit and they couldn't manage so they taɪd taɪd her and he was delighted and they got married.

Written narration

She was very nice to get with it not no utill till the, that she get to found out. The glass slapper fit of the goor. On the go the go to get marriaged.

Appendix 5.3 (Continued)

Narrations of Cinderella story by participants
(broad transcription of spoken and written formats)
(*unw* – unintelligible word ; *ilw* – illegible word) in brackets [*assessor*]

5.3e C5
Spoken narration

Eh………..I just went for a taxi ride [aha] eh………….gona…[*unw]* and a driver eh….

Unable to attempt written version

5.3f C6
Spoken narration

Ah..a [*unw]* this one Cinderella was a beautiful princess who brought up beside her two…step sisters. But eh your prince vaɪtə to the ball…ah.. to become his princess right. But the step sisters has to make Cinders Cinderella work doing eh all his bidding and st tooing and froing from his eh eh to and froing from them right. Eh…now…eh when the the young prince naʉnst his bɔ: Cinderella had wanted to go to the ball right, right but they the the how can I put it the eh not the witch no the fairy godmother wʌ granted him a wish granted her a wish "You be home for midnight" right eh., you you ha eh "Your carriage will turn into pʌmpɪs and rat" eh right and eh that's it. So dʉli the ..Cinderella went to the ball puffed up [*unw*] the that is eh so he..she was running for a ball [*unw*] she was running from the ball the beautif…the handsome prince picked the beautiful glass slipper eh eh an said aloud by the way "I wish wʌ I I'll put the ..I was going to say the boot in (laughing) I'll put the sɪpə on the young girl who who.. this fits ok. And she duly will [*unw]* to the kingdom and trying all the so eh trying the stɪp and I on all the slipper..[*unw*] he tried to a the ugly sister and said no I can't find this beautiful pɹɪsəʔ and low and behold Cinderella poked her feet in the door…ah [*unw]* (laughing) and oh yes "Cinderella you didn't tell me about Cinderella" and low and behold the slipper fitted her ok and they lo loved happily ever after.

Written narrations

PRINCE MET CINDERALLA AT THE BALL AND ASKED HER WHERE SHE GOING FROM

5.3g C7
Spoken narration (lots of gesture)

Em he was, he was got, he was got a (un) and he lovely. Then he got got married. And he goes they ones here…..down here…..down stair, and he says no…. see so took up stairs….youse down here with the time….(un) of the times and they have…there…..everytime they go there and there. Come on now. Here there, Then she says to ah my please I could go there. And (un) lovely come out. And he says one time you must come out. One. So down and he goes….(un) lovely….(tttttt) and he was lovely and he goes lovely and he goes (kissing noises) and he said (whhh) and he says ah god look at him. So my sister come out look at (tututut) and we went out and he says….what that…what that one……all of this one ….no and he said…[phone rings] have you…and (un) and he goes (ttttt) and goes lovely and lovely that mine and all the times to get.

Unable to attempt written narration

Appendix 5.3 (Continued)

Narrations of Cinderella story by participants

(broad transcription of spoken and written formats)
(*unw* – unintelligible word ; *ilw* – illegible word) in brackets [*assessor*]

5.3h C8

Spoken narration

Cinzeralla went to biə she had eh she had eh god [unw] she's got fɹi other skisters eh yeh she called eh and she had to be home by tɛlv o clock tonight…eh…eh and she drops the stʉ or something she drops the stʉ and eh.. eh I can can't any more [*can you remember what happened then?]* no I can't no [*what happened at the end?]* I don't think I can…no..no..no *[was it a happy ending do you think?]* oh aye. Can ɹɛmə can ɹɛmə

Written narration

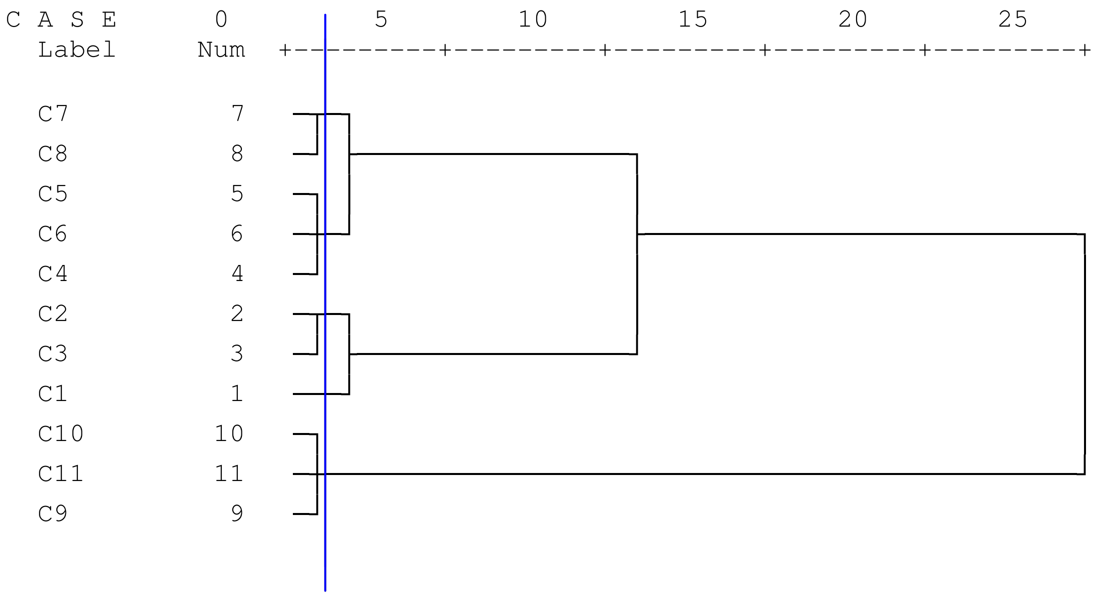
CINERDA GOT BALL BALL SHE SHOP

Appendix 5.4

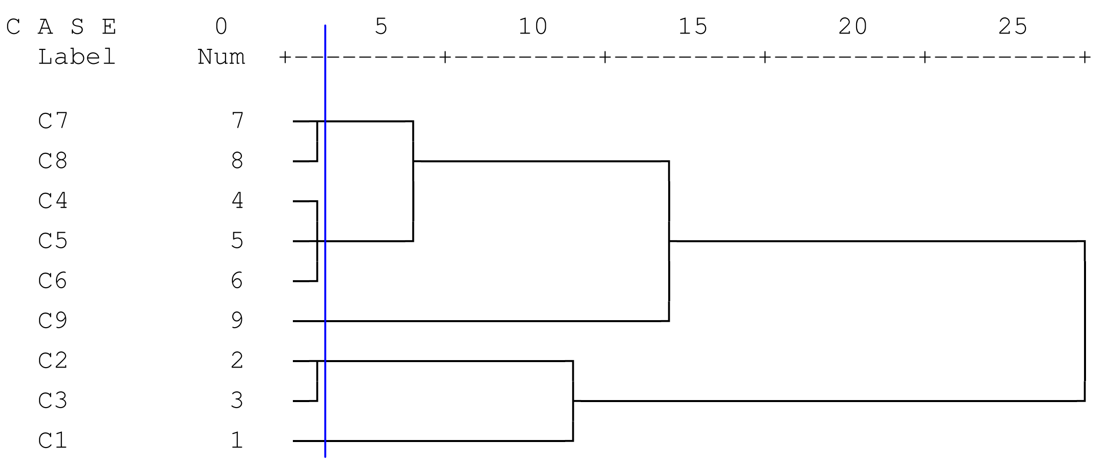
Hierarchical cluster analyses

Dendrogram using Average Linkage (Between Groups)
Rescaled Distance Cluster Combine

5.4a Immediate recall



5.4b Delayed recall

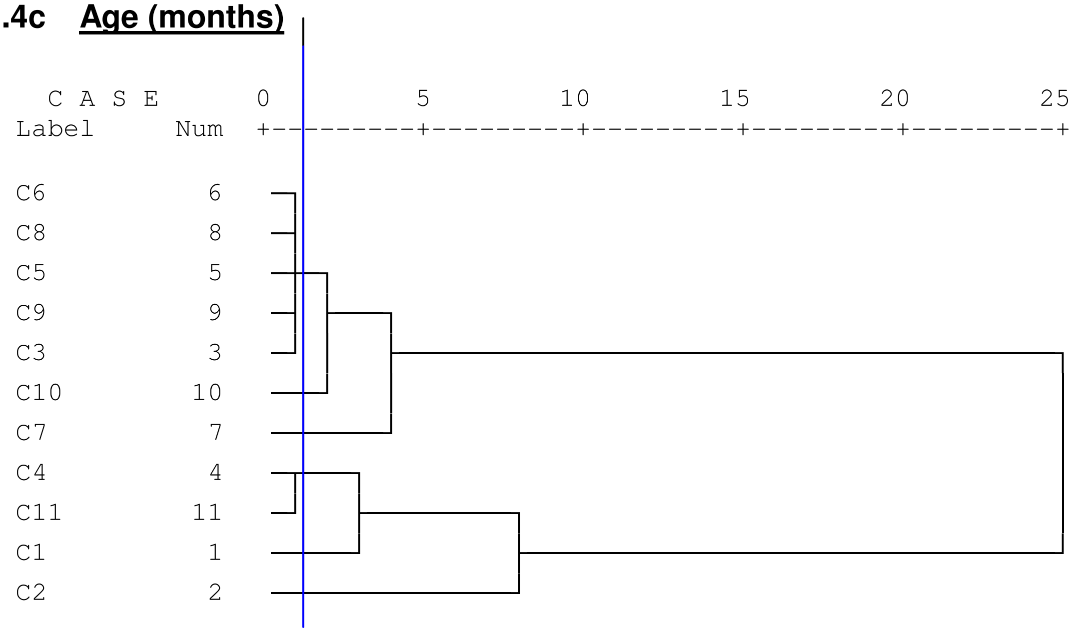


Appendix 5.4 (continued)

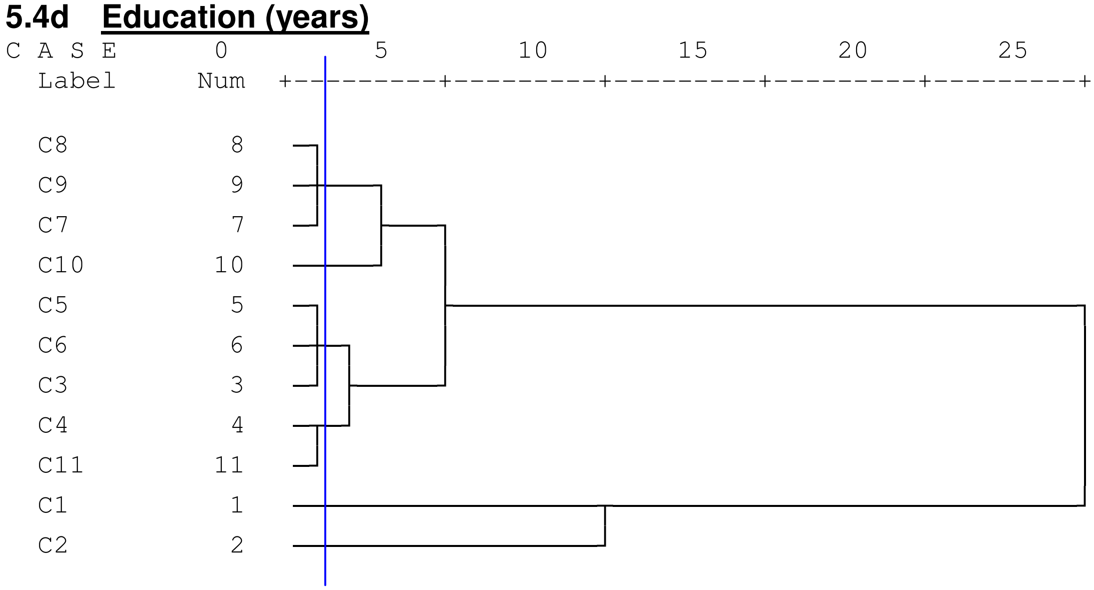
Hierarchical cluster analyses

Dendrogram using Average Linkage (Between Groups)
Rescaled Distance Cluster Combine

5.4c Age (months)



5.4d Education (years)

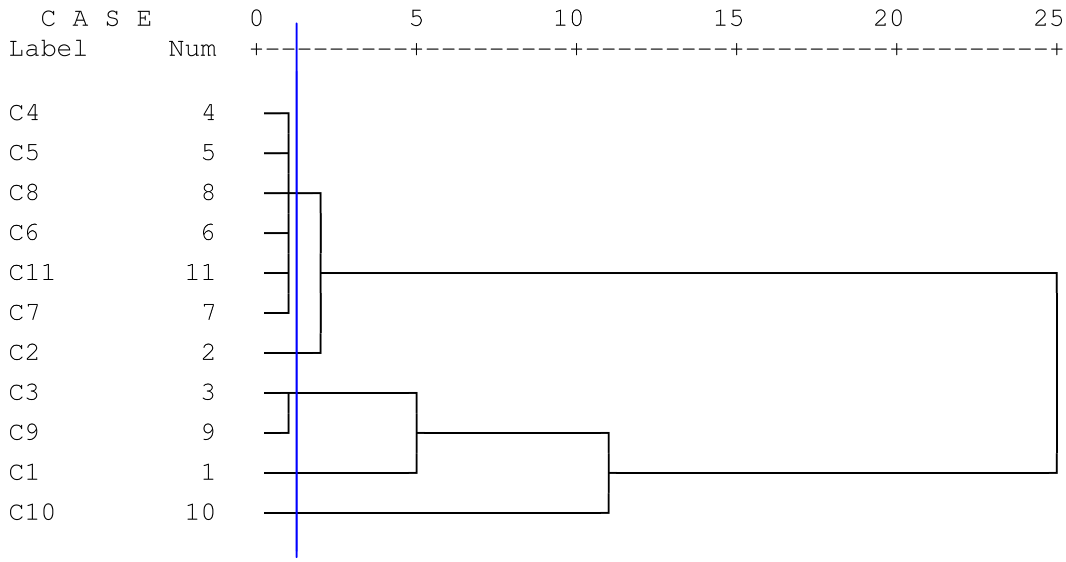


Appendix 5.4 (continued)

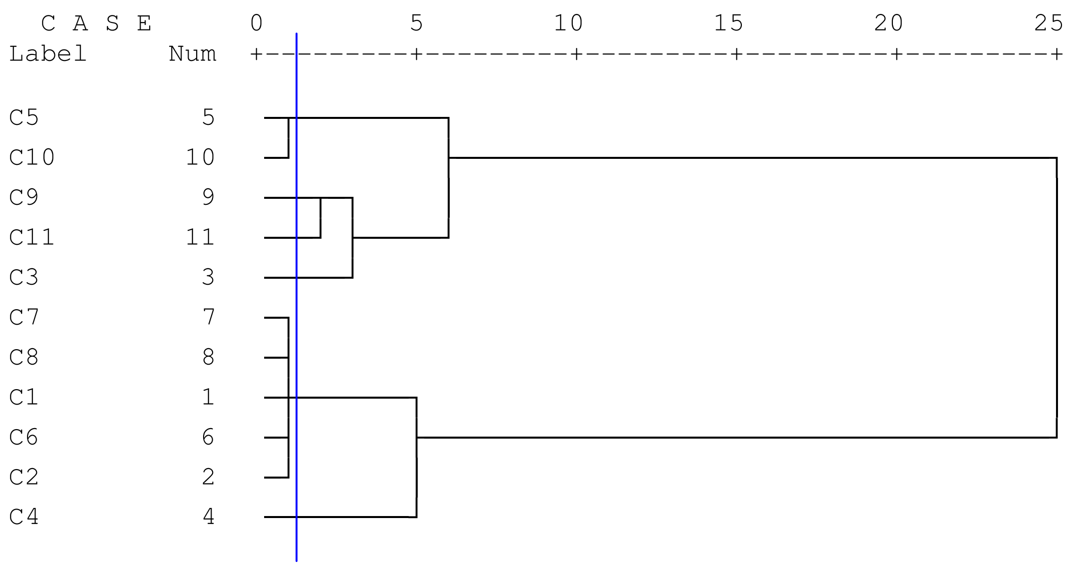
Hierarchical cluster analyses

Dendrogram using Average Linkage (Between Groups)
Rescaled Distance Cluster Combine

5.4e Months post-stroke



5.4f HADs anxiety rating

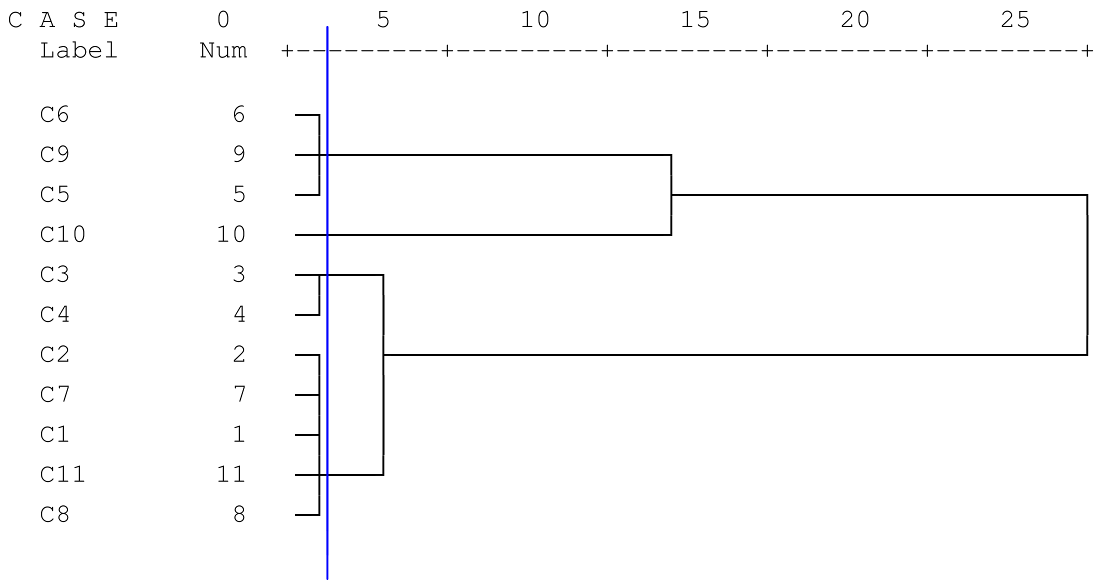


Appendix 5.4 (continued)

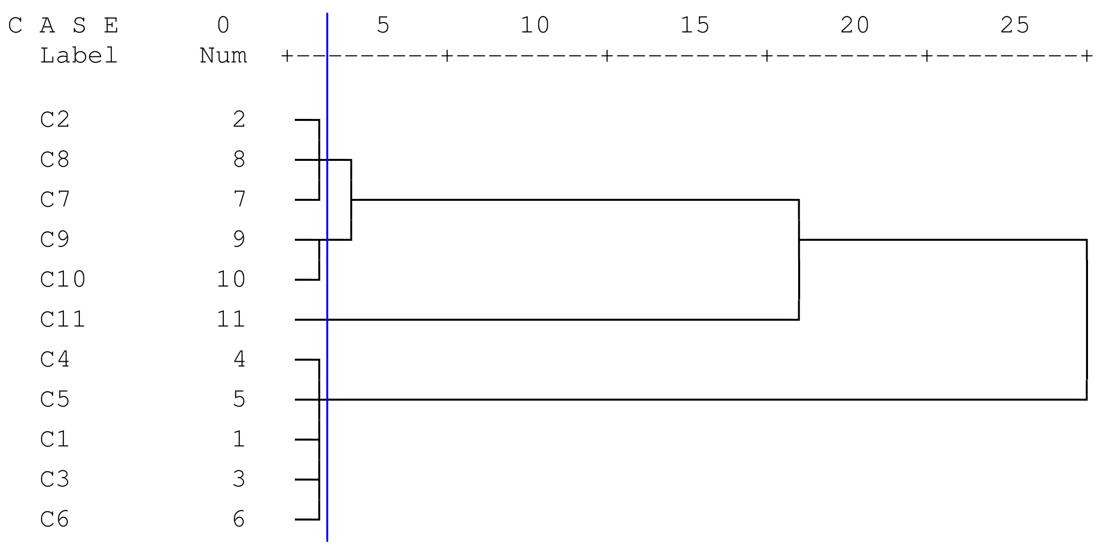
Hierarchical cluster analyses

Dendrogram using Average Linkage (Between Groups)
Rescaled Distance Cluster Combine

5.4g HADs depression rating



5.4h Severity of aphasia

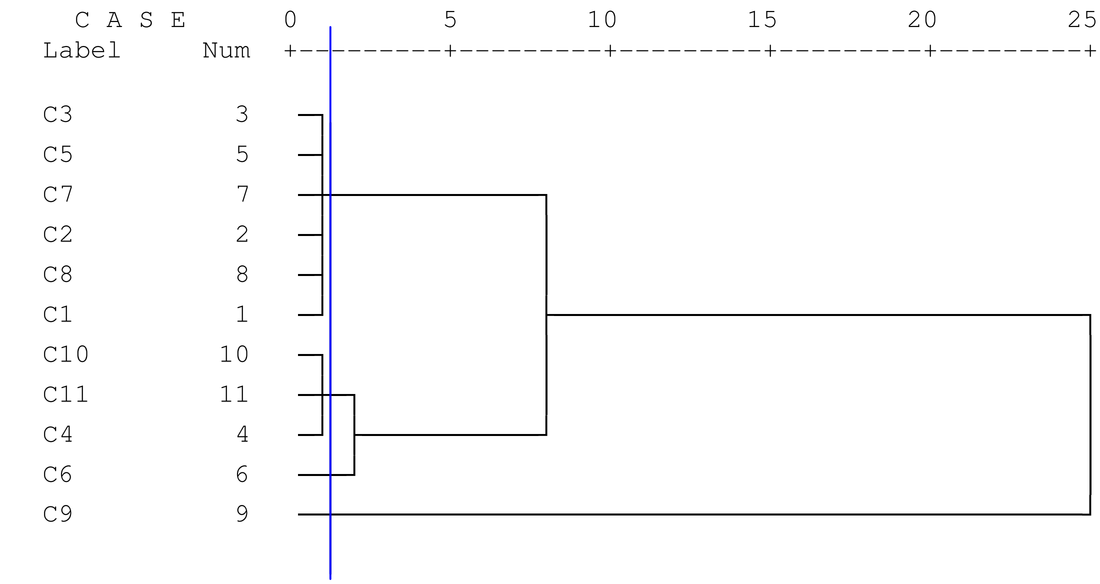


Appendix 5.4 (continued)

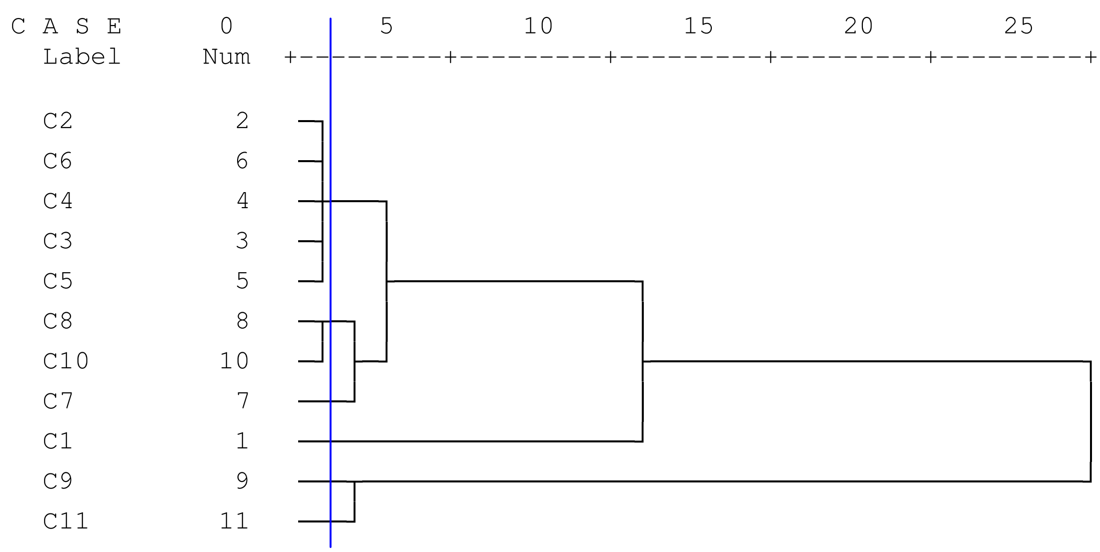
Hierarchical cluster analyses

Dendrogram using Average Linkage (Between Groups)
Rescaled Distance Cluster Combine

5.4i **Attention**



5.4j **Memory**

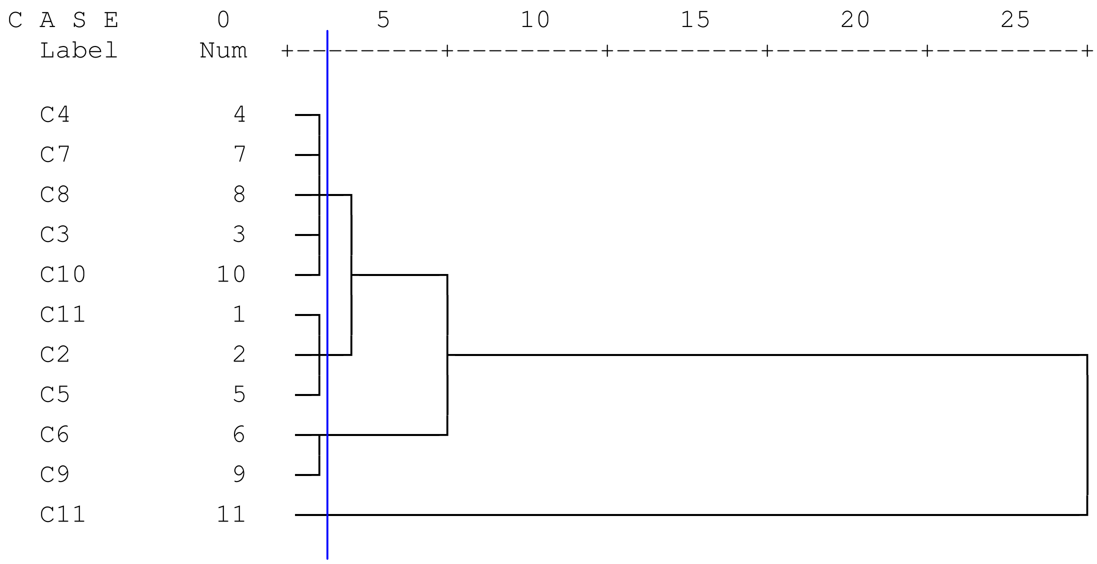


Appendix 5.4 (continued)

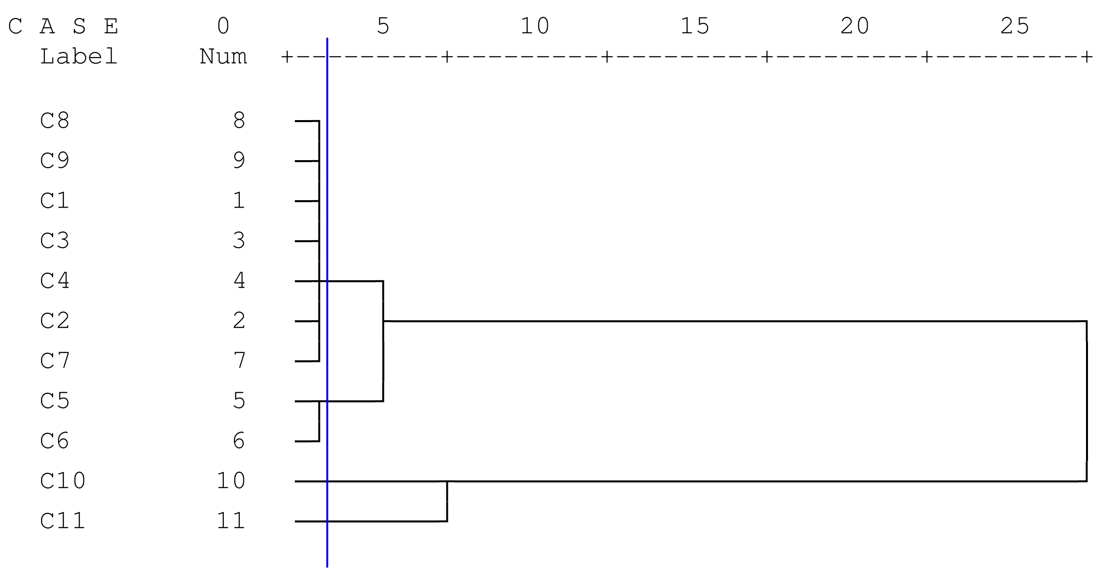
Hierarchical cluster analyses

Dendrogram using Average Linkage (Between Groups)
Rescaled Distance Cluster Combine

5.4k <u>Executive function</u>



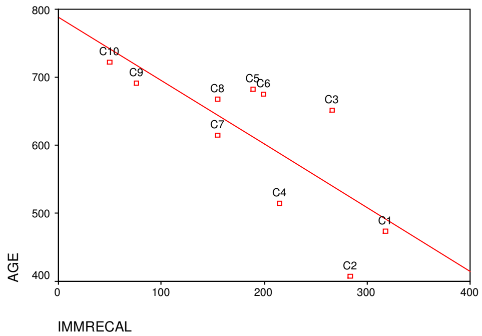
5.4l <u>Non-linguistic route learning</u>



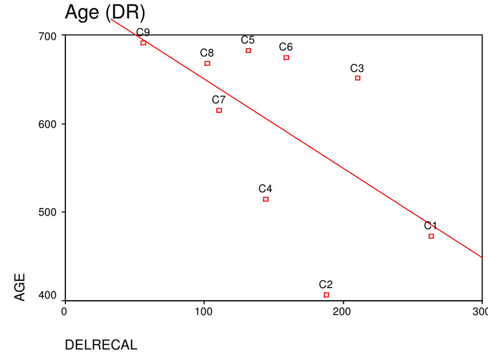
Appendix 5.5

Group correlation scatterplots for immediate and delayed recall

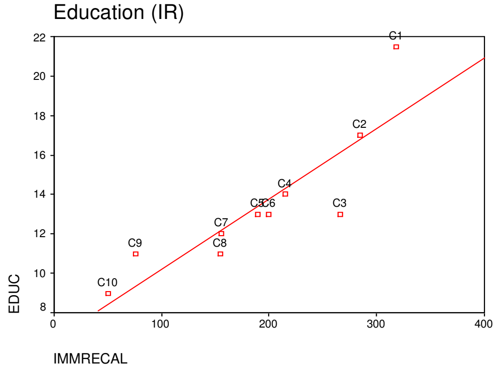
Age (IR)



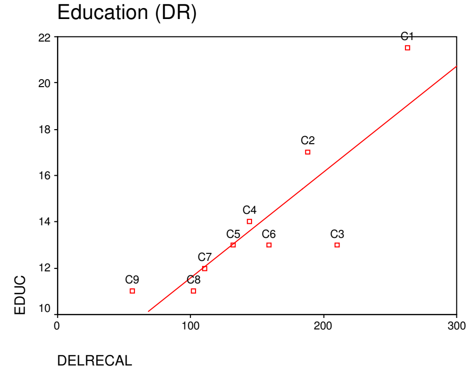
Age (DR)



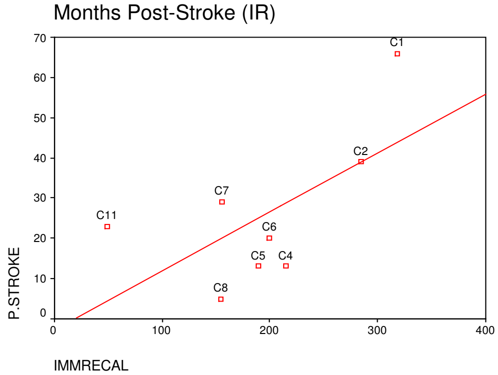
Education (IR)



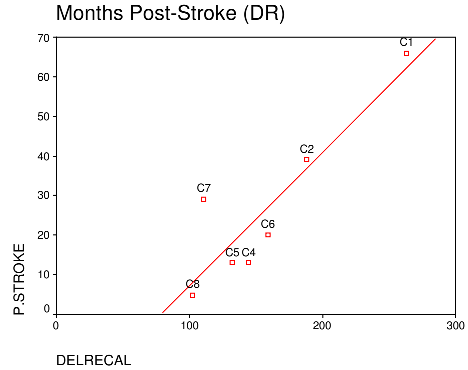
Education (DR)



Months Post-Stroke (IR)

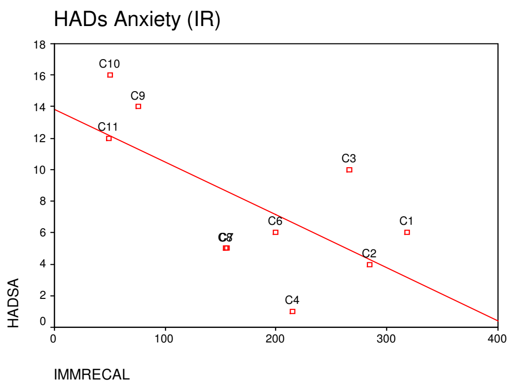


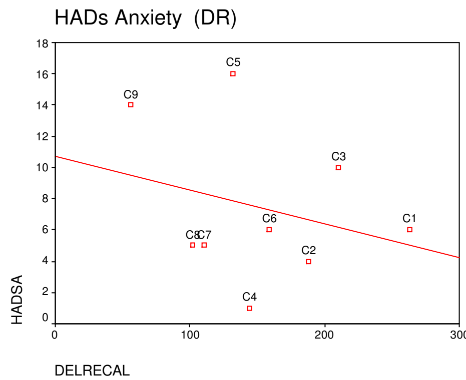
Months Post-Stroke (DR)

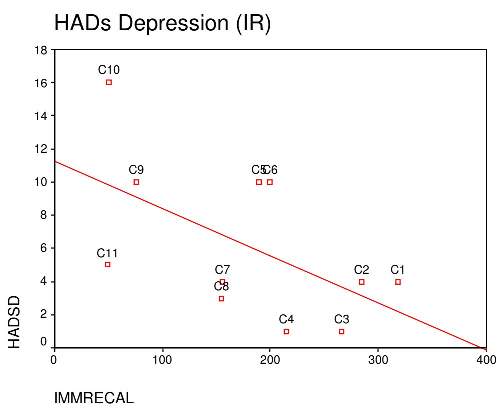


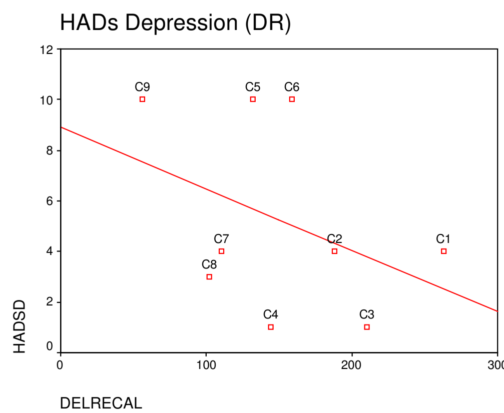
Appendix 5.5 (continued)

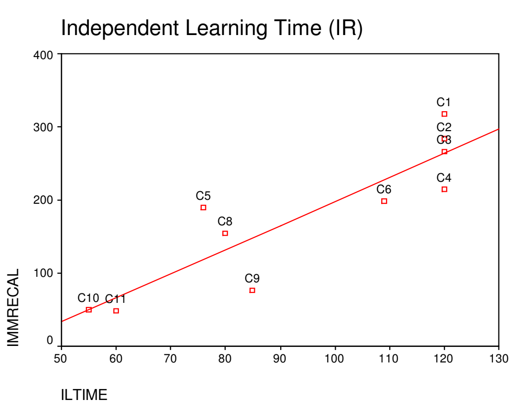
Group correlation scatterplots for immediate and delayed recall

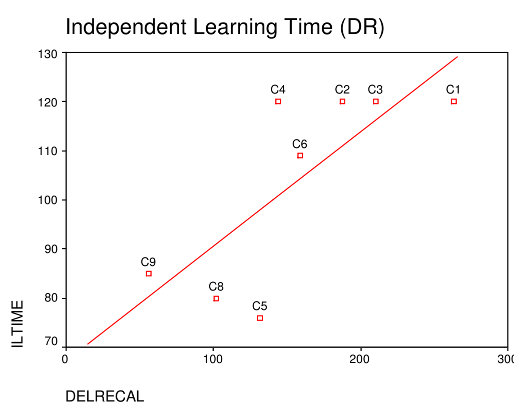








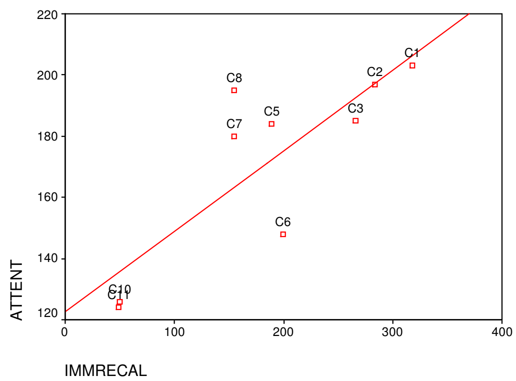




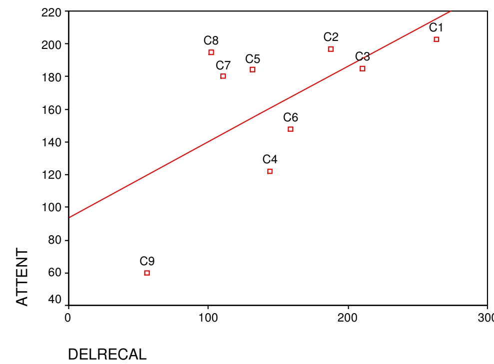
Appendix 5.5 (continued)

Group correlation scatterplots for immediate and delayed recall

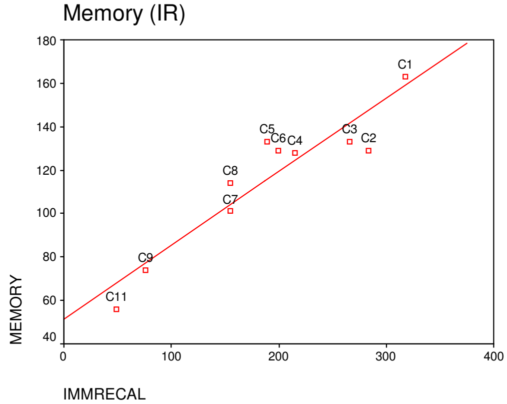
Attention (IR)



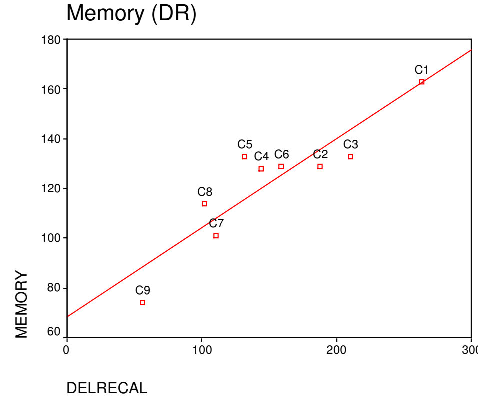
Attention (DR)



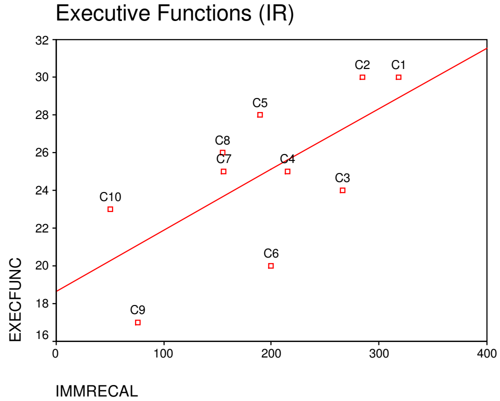
Memory (IR)



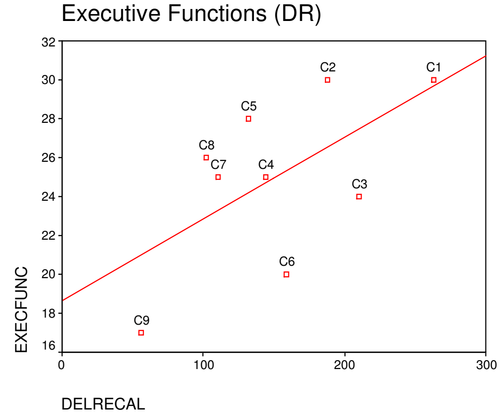
Memory (DR)



Executive Functions (IR)



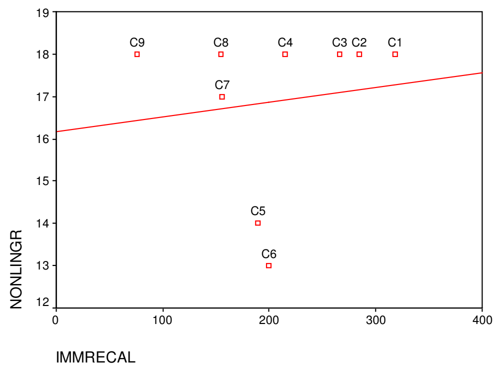
Executive Functions (DR)



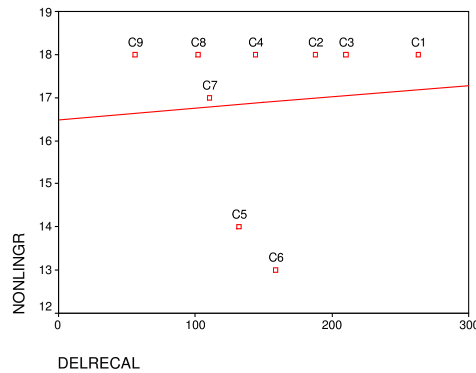
Appendix 5.5 (continued)

Group correlation scatterplots for immediate and delayed recall

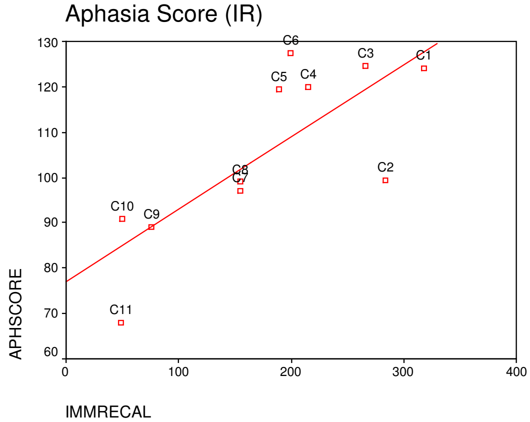
Non-Linguistic Learning (IR)



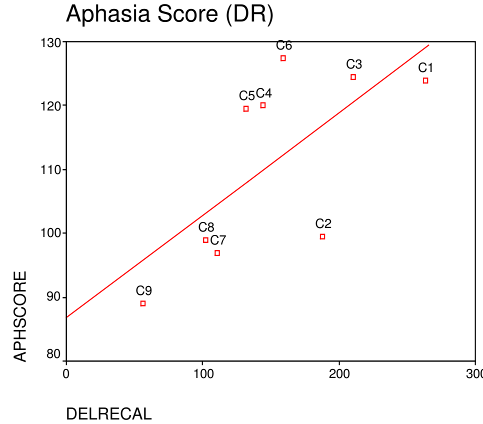
Non-Linguistic Learning (DR)



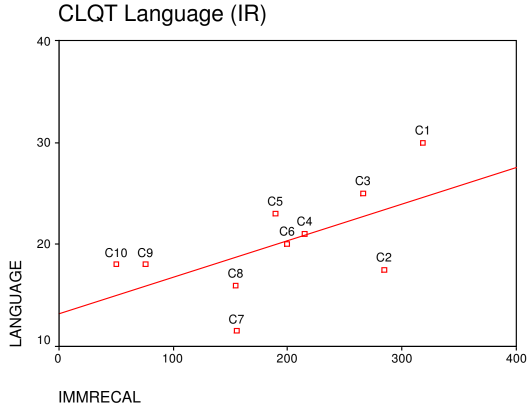
Aphasia Score (IR)



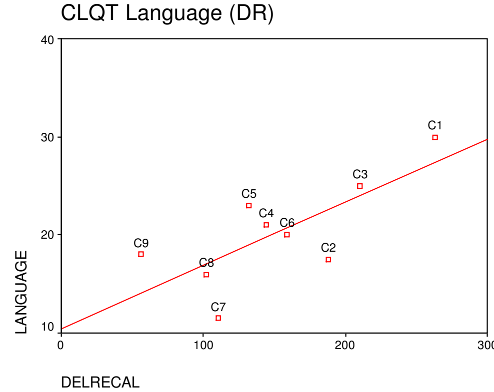
Aphasia Score (DR)



CLQT Language (IR)



CLQT Language (DR)



Appendix 5.6

Total recall of stimuli for immediate and delayed recall (new words)

Immediate recall			Delayed recall		
Creature	**Total times recalled**	**Training session number**	**Creature**	**Total times recalled**	**Training session number**
futarg	134	1	zoodop	86	3
curvol	128	4	silvark	86	3
feetokel	126	2	dreeple	83	1
maytor	126	2	futarg	80	1
vintrok	125	3	snaitle	80	4
snaitle	121.5	4	curvol	80	4
shorpine	120	1	popkinel	79	3
lundril	119	2	wangor	79	4
traigol	119	4	maytor	79	2
wangor	118.5	4	feetokel	77	2
yamtork	118	4	pentar	77	1
zoodop	117	3	yamtork	75	4
popkinel	116	3	sartle	73.5	1
sartle	114	1	shorpine	72.5	1
hamekin	114	3	vintrok	72	3
pentar	114	1	ponchino	71	2
ponchino	112	2	traigol	67	4
dreeple	112	1	junfliz	66	2
silvark	108	3	lundril	65	2
junfliz	106.5	2	hamekin	60.5	3

Appendix 5.7

Total recall of tasks for immediate and delayed recall (assessments)

	Immediate recall			Delayed recall
Recognise (A)	165		Recognise (A)	168
Syllable completion	163		Picture/syllable	158
W-P match (name) O	162		Recognise (O)	146
Recognise O	159		Syllable completion	140
W-P match (skill) A	159		W-P match (name) (O)	119
W-P match (name) A	158		W-P match (name) (A)	107
Categorisation I	153		W-P match (skill) (A)	103
Picture/syllable	150		Read aloud	92
W-P match (skill) O	148		W-P match (skill) (O)	88
Food	139		Name (written)	74
Name (written)	128		Categorisation (I)	67
Categorisation O	123		Habitat	64
Read aloud	113		Food	62
Habitat	109		Categorisation (O)	54
Name (verbal)	97		Name (verbal)	42
Skills	71.5		Skills	16.5